Psychological and Physiological factors affecting exercise tolerance in Chronic Bronchitis

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ABSTRACT

Disability from chronic bronchitis and emphysema imposes a heavy burden on society, and recent statistical evidence suggests that it will continue to do so. In this thesis I have examined psychological and physiological factors which may affect disability in chronic bronchitis. The 12 minute walking distance is a good measure of overall disability, but was shown to relate poorly to measured pulmonary function. Perceived exertion, however, strongly correlated with walking distance as did measures of mood and certain attitudes and beliefs of the patients towards their illness, treatment and towards exercise.

The degree of hypoxia and hypercapnia did not relate to exercise tolerance or perceived exertion, and examination of subgroups of patients - so called 'pink puffers' and 'blue bloaters' - revealed no difference in their disability.

Proportionate and disproportionate disability may be seen as a continuum. An index of disproportionate disability was therefore derived from the ratio of standardized scores of walking distance and vital capacity. Perception of exertion and also attitudes and beliefs of patients correlated with this index of disproportionate disability. In addition certain key questions, thought to identify psychogenic breathlessness, correlated with disproportionate disability.

Disability in chronic brochitis cannot easily be predicted from measured ventilatory impairment, and psychological factors are important. It is suggested that they should be taken into account when assessing the outcome of rehabilitation programmes or new therapies.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Page

LIST OF ABBREVIATIONS

Abbreviation	Term in Full
DBQ	Disproportionate breathlessness questionnaire
DDZ	Index of disproportionate disability
DLCO	Transfer factor (diffusing capacity) for the lung for carbon monoxide
FEV_1	Forced expiratory volume in one second
FVC	Forced vital capacity
GHQ	General Health Questionnaire
KCO	Transfer coefficient, or transfer factor expressed per litre of alveolar volume
MAACL	Multiple Affect Adjective Check List
2, 6, 12 - MD	The distance walked in two, or six, or twelve minutes
MVV	Maximum voluntary ventilation
$PaCO_2/PaO_2$	Arterial blood carbon dioxide/oxygen tension
RPB	Rating of perceived breathlessness
RPE	Rating of perceived exertion

LIST OF ABBREVIATIONS (cont'd)

RV	Residual volume
TLC	Total lung capacity
VAS	Visual Analogue Scale
VO_2 MAX	Maximum oxygen consumption
'3' score	A standardised score, i.e. $'3'\ x, = \frac{X, - \bar{x}}{SD}$

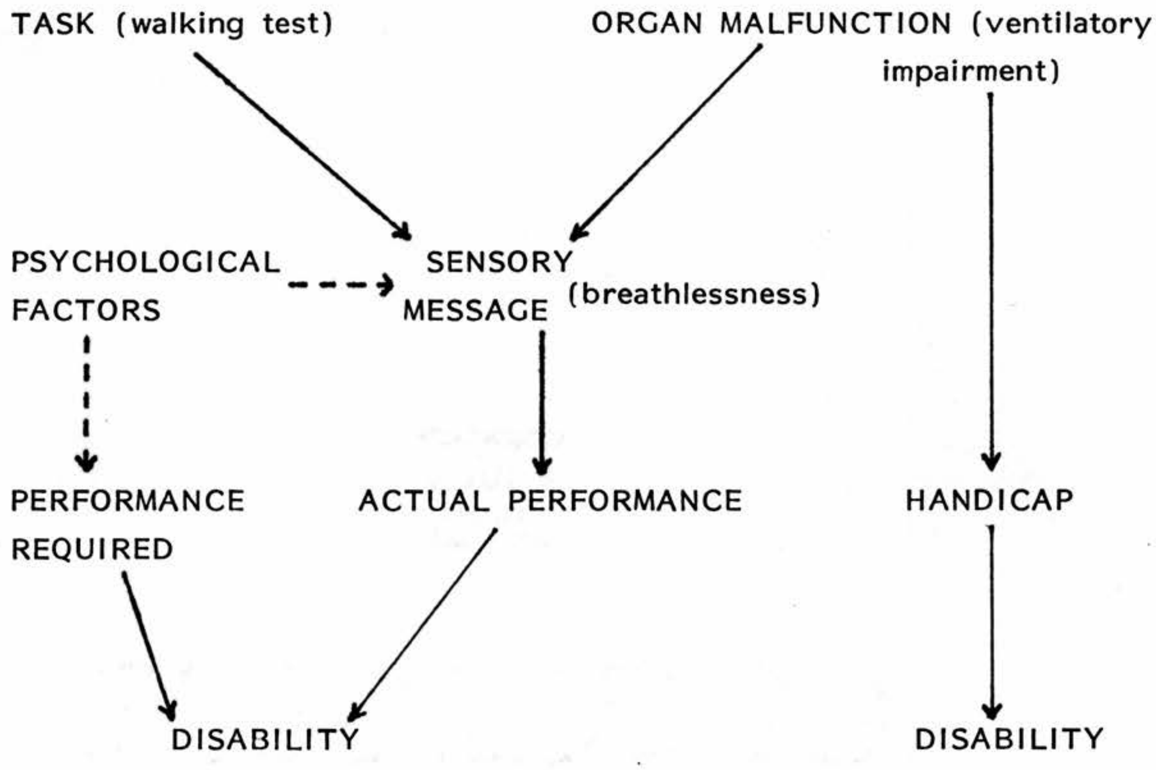
INTRODUCTION

This thesis is concerned with psychological and physiological factors which affect exercise tolerance and disability in chronic bronchitis. 'Disability' in its widest sense implies interference with the normal activities of life whether at home, at work, or in personal relationships, from a chronic disease (1). In chronic respiratory disease the interference with these aspects of life is largely due to breathlessness experienced on exertion or even at rest. It is thus a variable symptom which may depend on the usual activities of the patient. Clearly a sedentary unemployed man is less disabled with moderately severe ventilatory impairment than another man in work with the same degree of impairment. Measurement of disability is necessarily imprecise, depending as it does on social, personal and psychological factors. 'Handicap', however, can be measured more precisely if one defines it as the physical limits of what a patient can do e.g. his performance of an exercise test. Ventilatory impairment can be simply and accurately measured, as can respiratory gas exchange, and the relationships between impairment, handicap and disability may be considered thus (2):

IMPAIRMENT	(FEV_1 VC etc)
↓	↓
HANDICAP	(exercise test)
↓	↓
DISABILITY	(interference with daily living)

An amplification of this scheme was suggested by McGavin (3) and I have added in parenthesis a respiratory component and suggest where psychological factors may modify response (Fig 1).

Fig 1. Relationships between impairment, handicap and disability.



A psychological 'input' may be important at the level of the 'sensory message' (breathlessness) and the expectation of the patient (performance required).

Bearing these relationships in mind the thesis sets out to examine the hypothesis that psychological factors may affect exercise tolerance of patients 'disabled' by chronic airflow obstruction.

Exercise tolerance has been measured by a self-paced walking test (the twelve minute walking test or 12MD), chosen because it reflects an everyday activity and may therefore measure more closely the degree of 'disability' than a formal laboratory exercise test which may more accurately reflect the degree of physical handicap. Previous studies of the 12 MD (reviewed later) have consistently demonstrated its great variability amongst bronchitis patients with similar degrees of impairment, and it is this variability which provided the initial stimulus for the studies in this thesis. It seemed more likely that psychological factors may affect a test of everyday activity than would physiological factors.

Two studies examine the hypothesis. The first is a study of fifty patients who underwent tests of respiratory function, a twelve minute walking test and a psychological examination. The second and shorter study essentially compliments the first, but specifically examines whether psychological and physiological factors affect walking tests of shorter duration.

The review of the literature is concerned with epidemiological aspects of chronic bronchitis, physiological aspects of chronic airflow obstruction, exercise testing and breathlessness, and psychological aspects of chronic respiratory disease.

CHAPTER 1

EPIDEMIOLOGICAL PHYSIOLOGICAL AND PSYCHOLOGICAL ASPECTS OF CHRONIC BRONCHITIS

1(1) PREVALENCE, MORBIDITY AND MORTALITY OF CHRONIC BRONCHITIS

The patients studied in this thesis suffered from chronic bronchitis and were disabled by chronic airflow obstruction. Without implying any causal link between these features, for the purpose of characterising the group of patients studied I have used the simple definition introduced by the MRC Research Committee in 1963 to describe a condition characterised by chronic cough with sputum production for at least 3 months during 2 successive years (4). In addition they were all shown to have chronic airflow obstruction. Definitions of chronic bronchitis have often been vague in an attempt to embrace airflow obstruction with chronic cough e.g. chronic bronchitis and emphysema, chronic obstruction lung disease (C O L D), or chronic obstructive pulmonary disease (C O P D). However, with the realisation that chronic airflow obstruction may be due to either emphysema or inflammation in small or large bronchioles (5, 6 and 7) I have avoided these terms and keep to chronic bronchitis and airflow obstruction unless quoting from studies using other terms.

In the United Kingdom chronic bronchitis and emphysema is responsible for the largest single medical cause of loss of work. In 1973/74, 31 million days of work were lost due to chronic bronchitis (9.7% of all lost working days) and in 1980/81 this had fallen only slightly to 28.4 million (8.2%) (8). In Scotland over approximately the same period a similar pattern emerges. In 1970 10.5% of all working days lost were due to chronic bronchitis and 10 years later this had only fallen to 9.5% (9).

Days lost from work indicate the prevalence amongst the working population. The true prevalence is difficult to measure, although a number of post-war surveys have been carried out in general practice to try to measure the size of the problem. In 1954 Dr John Fry, surveying his patients in the South London practice of predominantly social class 3 and 4, found an incidence of 3.13% in men and 2.5% in women (10). Using approximately the same criteria, the much larger Royal College of General Practitioners survey found a prevalence of 8% in men and 3% in women (11). The earlier survey was carried out in a non-industrial practice in surburban London, the larger survey was nationwide.

Surveys carried out in industrial areas indicate a much higher prevalence. For example, in a 1957 survey in Newcastle the prevalence was much higher in the lower social classes (12). In social class 1, only 5.3% of men were considered to have chronic bronchitis whereas in social class 5, 22.9% were found to have chronic bronchitis. Unfortunately, these figures for prevalence have not changed much over the years, although the mortality may have improved. From a survey in 1980 the percentage considered by general practitioners to be suffering from chronic bronchitis rose from 6% in social class 1 to 26% in social class 5 (for men aged between 40-64) (13). Housing and social conditions are still of great importance. Another study in the North East of England in 1985 specifically looked at local authority housing conditions, and related these to the incidence of respiratory disease (14). Respiratory symptoms were significantly related to poor housing conditions when age, class, smoking and working were all constants. Old property appeared to be worse, as did flats, and particularly high rise flats compared with low or medium rise flats.

Numbers seeking invalidity benefit also indicate the size of the problem - in 1982 60,000 and 5,000 women were in receipt of invalidity benefit because of respiratory disorders (15). A study of those claiming benefit in North Sea England revealed that only half had seen a respiratory specialist, although on examination, 88% had definite chronic respiratory disease (67% chronic bronchitis). Twenty percent of all examined had normal lung functions and nearly a third of these were thought to have mainly psychological problems (16).

Mortality in the United Kingdom has fallen steeply since the earlier post-war years, but this fall has levelled off since the late 1960's. Indeed, over the last 9 years the mortality has remained constant. In England in 1974, 26,598 deaths were attributed to bronchitis, emphysema and asthma and by 1983 this had only fallen to 26,257 (17, 18). Scotland has always had a slightly lower death rate than England. In 1982 the crude death rate for men was 430 per million in scotland and 489 per million in England and Wales (19). The death rate for women appears to be the same (2000 deaths per million). These differences have been noted over a long period and surveyed twice by Crofton, covering the years 1940 to 1967 (20, 21).

The factors which have led to this fall in mortality are most likely to be the reduction in air pollution and in cigarette smoking (22). The reduction in industrial and atmospheric pollution from the 1950's, when the United Kingdom had the most polluted atmosphere in the world, by the Clean Air Acts and reduction in open coal fires led to a fall in smoke emission from 1952 to 1968 of 84%. Cigarette smoking has also decreased since the 1950's although less so amongst the lower social classes 4 and 5 (see Table 1).

Thus disability from chronic bronchitis continues to be a major burden for society. It seems unlikely that the prevalence and mortality will change significantly while social conditions and smoking habits remain. It may of course become more regional in its distribution, as attitudes and habits change in the more affluent areas. Unemployment and poverty in an industrialised area may even contribute to an increase in chronic respiratory disease and this should be an area for further epidemiological study.

Table 1 Percentage Of Cigarette Smokers In The United Kingdom 1958-1978

		Men		Women	
	Social Class	1958	1978	1958	1978
I	Professional	54	25	43	23
I	Employers and Managers	54	37	43	33
II	Intermediate & Junior Non-manual	58	38	43	33
III	Skilled manual	60	49	42	42
IV	Semi-skilled	54	53	42	41
V	Un-skilled	61	60	42	41

1. Chief Medical Officer, England & Wales 1977 On the State of the Public Health. London. HMSO.

2. Office of Population Censuses & Surveys 1979 General Household Survey 1978: Cigarette Smoking. OPCS Monitor. Ref. GH579/2

1(2) RELATIONSHIP OF PHYSIOLOGICAL MEASUREMENTS TO DISABILITY IN CHRONIC BRONCHITIS

An essential part of the assessment of any patient complaining of breathlessness is a simple pulmonary function test, e.g. measurement of FEV_1 and VC by spirometry. This easily characterises the severity of airflow obstruction if present, and the degree of ventilatory impairment. However, within groups of patients with chronic airflow obstruction, it is not easy to predict how handicapped or disabled they might be. In 1952 Hugh-Jones related exercise performance in bronchitic patients to a dyspnoea grade essentially the same as the MRC grade currently in use (23). Only a low correlation between exercise performance and dyspnoea grade was found and the overlap between groups was such that more than half of the patients had results which could place them in any grade of dysnoea but the most extreme.

Similar observations were made by Capel who related ventilatory capacity to a dyspnoea grade and found an wide scatter of results so that the degree of impairment could not be predicted from the degree of dyspnoea (24). Essentially similar findings have emerged from other studies (25, 26, 27, 28, 29). Burrows carried out detailed pulmonary function studies in a large group of patients and found that simple measurement of FEV_1 correlated most closely with a dyspnoea grade (27). Studies of arterial gases have shown that the degree of hypoxia or hypercapnia does not usefully predict effort intolerance in chronic bronchitis (29, 30, 31). In Smart's study the FEV_1 was again found to be the most sensitive guide to the degree of effort intolerance except in those where a low arterial oxygen saturation and carbon dioxide retention reflected severity of ventilatory impairment. Hypercapnia is therefore found in the most disabled, but is not an independent prognostic factor. Arterial blood gases taken at rest however do characterise the variation in types of disturbance seen in chronic bronchitis from the "pink puffers" to the "blue bloaters" described by Dornhorst, and further characterised by Ogilvie, Richards, Fletcher and Burrows (32, 33, 34, 35, 36).

1(3) EXERCISE TESTING IN CHRONIC AIRFLOW OBSTRUCTION

Exercise testing provides a more direct approach to evaluating dyspnoea than static pumonary function tests, using the engineering principle of 'testing under load'. However, as some of the above studies have shown, there is still a great overlap between exercise performance and subjective dyspnoea and disability. Exercise tests may be formal in a sophisticated exercise laboratory when detailed physiological measurements can be made during progressive work load tests, or at submaximal levels of work. They also can be informal, and test familiar activities like stair climbing or walking.

Formal exercise testing

There is a wide variation in the physiological response to exercise amongst patients with chronic airflow obstruction and much of this variation is due to the different physiological characteristics of 'pink and puffing' 'Type A' and 'blue and bloated' 'Type B' patients (Table 2). The distinguishing features separate the extreme ends of a spectrum where many patients occupy an intermediate position. Many studies comparing these groups also use different criteria and are therefore not easily comparable. For example, where a radiological classification of emphysema is used to type patients (38, 43) the difficulties in relating radiological to pathological findings may not be fully taken into account (40, 41). It seems more sensible to consider these two groups as two ends of a purely physiological spectrum and not impute an underlying pathological diagnosis with certainty.

In general when a patient with chronic airflow obstruction stops exercising, it is because he has reached his maximum exercise ventilation (VEmax), which bears a close relationship to the maximum voluntary ventilation (MVV). MVV may be measured directly or estimated from the $FEV_1 \times 35$ (44) or for patients with FEV_1 of <1.2 L, $FEV_1 \times 18.9 + 19.7$ (45). Failure to achieve a VEmax of near the measured or predicted MVV during a progressive exercise test suggests that factors other than lung disease may be present, e.g., cardiac disease, weak respiratory muscles or, rarely, central insensitivity to CO_2 (46).

Table 2 Clinical, radiological and physiological characteristics of patients with chronic airflow obstruction (N = normal)

	'Pink Puffers' Type A		'Blue Bloaters' Type B	Reference
Clinical	weight loss		overweight	32,34,35,36,37
	not cyanosed		cyanosed	38,39
	no oedema		oedema	
	severe breathlessness		less breathlessness	
Radio-logical	Narrow cardiac shadow		cardiac enlargement	37
	'emphysema' ++		emphysema +-	
Physio-logical	$\downarrow$ VC	=	$\downarrow$ VC	
	$\downarrow$ FEV_1	=	$\downarrow$ FEV_1	
	$\uparrow$ TLC	$\gg$	$\uparrow$ or N TLC	
	$\uparrow$ RV	$\gg$	$\uparrow$ RV	
	$\downarrow$ D_LCO	$<$	$\downarrow$ or N D_L CO	33,35,36,
	$\downarrow$ KCO	$<$	N KCO	37,38,39
	$\downarrow$ Pa02	$>$	$\downarrow$ Pa02	
	N Sa02	$>$	$\downarrow$ Sa02	
	N or $\downarrow$ PaCO2	$<$	N or PaCO2 $\uparrow$	
	Elastic Recoil	$<$	N or slightly reduced Elastic Recoil	40

Abnormalities in gas exchange on exercise may provide further limiting factors in achieving a predicted maximum work rate, particularly if patients lie at the Type A end of the spectrum. Studies using approximately the same criteria showed that in Type A patients' VE rises more rapidly for a comparable FEV_1 and exercise ceases earlier with less total work load achieved (38, 42, 43).

From these studies, during this shorter rise to maximum ventilation the Pa02 may drop precipitously and the PaCO2 may rise. The measurements of ventilation and perfusion (V/Q) matching the ratio of physiological dead space to tidal volume (VD/Vt%) and the alveolar to arterial oxygen (A-a) difference, may actually improve in the Type B 'bronchitics', whereas they remain unchanged or increase in the Type A emphysematous patient. Again it can be difficult to predict what will happen in an individual case from static lung function, particularly as the degree of hypoxia on exercise cannot be predicted from the resting Pa02 (45). The best predictor seems to be the diffusing capacity. In Jones's study the arterial desaturation on exercise occurred in those with significant reduction in D_LCO, and in a recent study a D_LCO of <55% predicted was a good predictor of desaturation (47). However, in this study the FEV_1 also emerged as a useful discriminating factor, only slightly less sensitive and specific than D_LCO. Some patients with the Type B patterns of disease do desaturate on exercise and they seem to be patients with a higher pulmonary artery pressure at rest which increases sharply during exercise (48).

In conclusion most patients with the 'pink and puffing' pattern of disease develop hypoxia at cessation of exercise, whereas in the 'blue and bloated' patient ventilation rises more slowly and there may even be improvements in gas exchange. However, in those in the latter group with a high pulmonary pressure which rises on exercise, desaturation does occur. The high subjective breathlessness and rapid rise in VE on exercise in the 'pink puffers' patient have led physicians to think that this is the more disabling condition to have. However, when a group of 'pink puffers' and 'blue bloaters' were matched for ventilatory capacity and their exercise tolerance and breathlessness compared, no significant differences could be detected (49).

Similar changes in ventilation and gas exchange may be seen at submaximal levels of work load and it is clearly easier and safer to study patients with moderate to severe impairment at these lower levels (45). The indices of gas exchange VD/Vt% and (A-a) difference are also more accurately measured at submaximal loads as a steady state is more easily achieved. Effort and motivation are also less likely to influence results when measurements are made at these levels.

1(4) NON-LABORATORY EXERCISE TESTING

The ability to test a patient's exercise outside the laboratory is clearly available to all. 'Non-laboratory' exercise tests have the advantage that the exercise is more familiar to the patient than cycling or walking or a treadmill e.g. step climbing or corridor walking. Breathing through a mouthpiece with a nose-clip is essential for gas collections to measure VO_2 and VE in the laboratory. This may be uncomfortable for normal subjects and not least for patients with chronic airflow obstruction. The discomfort for some may lead to cessation of exercise for psychological rather than physiological reasons.

A number of these simple tests have been evaluated with respect to more formal testing. Edwards studied the exertion of stair climbing in normal subjects and bronchitics and found that whilst the power output achieved related to ventilatory capacity, the patients and normal subjects set their level of work to similar degrees of physiological stress (50). Performance of a self-paced walking test to assess response to exercise in the elderly over a standard distance was found to correlate significantly with the response to a progressive exercise test in a laboratory (51). Both these studies recognised that self-paced performance may be complimentary to a formal exercise test, yielding slightly different information about an individual's disability.

The basic requirements for such a test were suggested by McGavin (3).

a) It should be based on a familiar physical activity

b) It should not require sophisticated equipment

c) It should be of sufficient duration to put stress on aerobic performance

d) the work rate should be chosen and adjusted by the patient during the test

Incorporating these features, the twelve minute corridor walking test (12 MD) was devised. Patients were asked to cover as much ground as possible in twelve minutes, stopping only as necessary. As it is a test of time rather than distance, patients of all degrees of disability can complete the test. The twelve minute duration was based on the work of Cooper who compared the distance walked and run by a large number of servicemen (age 17 - 52 yrs) with their maximum work rate in a laboratory (52). He found a close correlation between VO_2 max and the 12MD ($r = 0.897$), and found the test highly reproducible. Katch found that the correlation coefficient (r) of VO_2 max with continuous moderately heavy work on a cycle ergometer rose from nil at two minutes to 0.7 at six minutes and to 0.78 at 12 minutes (53). Prolonging exercise duration beyond 12 minutes did not greatly strengthen the correlation.

Using the 12 MD in patients with chronic bronchitis, McGavin related the distance walked to static lung functions and VO_2 max measured on a bicycle ergometer (54). Reproducibility was assessed by repeating the 12 MD three times over different days. A significant increase was found between the first and second walk, but not between the second and third. The 12 MD (from the second walk) correlated significantly with FVC ($r = 0.46$; $p = < 0.05$) but not FEV_1 ($r = 0.283$; $p = > 0.05$), and significantly with VO_2 max ($r = 0.52$, $p = < 0.01$). Reproducibility was assessed by

Mungall and Hainsworth who measured the 12 MD on six occasions at two to three week intervals (55). The coefficient of variation (CV%) was ± 8.2%, which compared favourably with their measurements of FEV_1 (CV ± 14.8%), FVC (CV ± 11.1%) and D_LCO (CV ± 15%). If the results of the first two 12 MD's were ignored, the CV was reduced to only ± 4.2%. O'Reilly studied variation in the 12 MD and found an average within day variation to be 3.1% and after two week to be 9.1% (56). A study of patients completing four 12 MD's within a week suggested slightly greater mean variation of 16% between the first and fourth walk although the greatest increase occurred between the first and second attempt (57). In this study the 12 MD compared favourably with a step test and a cycle ergometer test in its lower variation. A factor which may affect consistency in the results is the degree of encouragement given to the patient throughout the walk.

Guyatt randomly allocated a group of patients with bronchitis or heart disease to receive encouragement or not during two and six minute walking tests. A clear increase in performance was seen amongst those who received encouragement (58). it is therefore very important to standardise the information given to patients, particularly in studies which include a walking test as an end point when testing a treatment effect.

In a further study by McGavin the 12 MD correlated more closely with patients' estimate of their exercise tolerance using an 'oxygen cost diagram' and perceived exertion following exercise, than with static lung function tests (59). It therefore appears to be a useful test of exercise tolerance which is adequately reproducible, and correlates both with maximum work load from a formal exercise test and patients' own perception of effort.

The 12 MD has been shown to be sensitive enough to detect changes in exercise tolerance in many studies of bronchitic patients following rehabilitation (60, 61, 62), bronchodilator therapy (63, 64, 65), and other drugs including Beta blockers, steroids, diazepam, promethazine and carbimazole (66, 56, 67, 68, 69). Oxygen therapy has also been shown to increase the 12 MD both in hypoxic bronchitis patients pulling an oxygen trolley, and the 6 MD in 'pink puffers' with oxygen carried by assistant or patient (70, 71).

The value of shorter walking times has been investigated since the introduction of the 12 MD. Butland found that walking pace was fairly constant during 2, 6 and 12 minute tests, although patients generally walked faster during the first 2 minutes of the test (72). Timing the third 100 metres of a 12 MD has been shown to correlate closely with the total 12 MD and may provide a useful alternative to the shorter walks now preferred (73).

In conclusion, non-laboratory exercise tests provide useful information about patients' disability and yet have a firm physiological basis. The 12 MD has been the most extensively investigated and bears a close relationship to VO_2 max, and subjective assessment of exercise tolerance. In general, the tests do not correlate well with static lung function tests, and yet reflect improvement when ventilatory capacity is increased pharmacologically. It seems likely that performance of these self-paced tests, reflect more closely overall respiratory disability than do more sophisticated measurements in an exercise laboratory.

1(5) BREATHLESSNESS AND ITS MEASUREMENT

The cardinal symptom of a diminishing ventilatory capacity, whether from an obstructive or restrictive lung disease, is shortness of breath on exertion. Although this appears a fairly simple phenomenon to understand, the actual relationship between measured ventilatory capacity and symptoms is far from direct. The first problem to consider is what do patients actually mean by "breathlessness".

Many patients mean many different things, and often qualify their complaints with descriptions of the component sensations of the symptom (74): 1) tightness in the chest 2) excessive ventilation 3) excessive frequency of breathing 4) difficulty in the act of breathing.

A common experience in normal people, akin to dyspnoea, is the feeling experienced on breath holding and much work has been done on the mechanism by which breath holdings leads to this discomfort. Although both hypoxia and hypercapnia have long been known to stimulate ventilation and may be thought to be involved in the production of dyspnoea on breath holding, it was shown in 1954 by Fowler that the discomfort of breath holding could be relieved by breathing a gas containing 8.2% oxygen and 7.5% carbon dioxide, which would actually increase hypoxia and hypercapnia (75). The discomfort on breath holding may also be relieved by breathing in very small volumes of one litre or less, and even by breathing against a closed mouth piece, or performing isovolume manoeuvres (76).

Guz and colleagues in 1966 were able to show prolongation of breath holding in normal subjects following vagal block, and later when studying patients recovering from spinal anaesthesia, showed that anaesthesia to T1 level did not alleviate the sensation at breakpoint (77, 78). From these experiments it was concluded that vagal rather than chest wall afferents stimulated the sensation of dyspnoea. In a later study blocking the phrenic nerve with local anaesthesia also prolonged breath holding time (36). There is thus evidence that the vagus and receptors in the diaphragm are important in the genesis of the discomfort of breath holding. The relief by isovolume manoeuvres and the nerve block studies certainly rule out the role of chemoreceptors in this phenomenon.

Breathlessness is also felt and tachyphnoea seen in pneumonia even when any hypoxaemia has been corrected. Trenchard and Guz studied this in an animal model of lobar pneumonia in cats, and found that the increased respiratory rate only occurred when the vagus nerve was intact (80).

The diaphragm does not seem to be involved in the detection of an added load to breathing simulating airways obstruction (81). Here a patient with C3 transection was compared with five patients with permanent tracheostomies. There was no difference between patients and controls in their ability to detect various inspiratory resistances, although in the case of the patient with C3 transection the only nerves connecting chest to brain were the vagi. Studying this same patient, the sense of irritation closely akin to 'chest tightness' induced by inhaling an irritant vapor was the same as the sensation produced in normal subjects (82). This also suggested that the vagus was responsible for carrying the afferent information.

Awareness of excessive ventilation is also recognised as dyspnoea, and may be produced either by exercise, hypoxia or hypercapnia (e.g. rebreathing carbon dioxide). In a study of normal subjects breathlessness was felt to be greater during carbon dioxide rebreathing than at the same levels of ventilation produced by exercise (83). The role of hypoxia in actually producing breathlessness has been little studied. However Guz has looked specifically at the effect on dyspnoea and hypercapnia and their stimulation (84). This was achieved by giving oscillatory hypercapnic and hypoxic ventilatory stimulation to give fluctuations in end - tidal $PACO_2$ and arterial oxygen saturation, for short stimulation cycles (0.5 mins) and longer cycles (2 mins). Levels of ventilation and dyspnoea were less for the shorter cycle stimulation than the longer, but when the subjects copied their ventilation responses with the end tidal CO_2 levels maintained, little or no dyspnoea was reported. From this it was concluded that the perception of breathlessness depended on effective reflex stimulation of the automatic medullary respiratory centre, rather than the detection of stimuli by chemoreceptors or pumonary mechanoreceptors alone.

These studies of the mechanisms by which afferent impulses reach the brain with information about the component symptoms of breathlessness i.e. chest tightness, excessive ventilation, difficulty in breathing, have greatly increased our understanding of the complexity of dyspnoea. However they do not explain the variability in the sensation felt by subjects or patients. Clearly much less well understood mechanisms at higher levels in the brain operate although no specific sites have been found. Hence psychological factors, particularly the state of arousal, and levels of anxiety and apprehension are very important. Comroe is often quoted from his description of dyspnoea encapsulating this idea as "the perception of a sensation by the patient and the reaction to that sensation" (85). Before going on to review work recognising the psychological aspects of dyspnoea in patients I wish now to consider the measurement of dyspnoea.

1(6) MEASURING BREATHLESSNESS

Most of the early studies of the relationship between breathlessness and ventilatory capacity use questionnaires along the lines of Capel and Smart (24) and Fletcher (86), adopted by the Medical Research Council. Patients were divided into five "grades" according to their degree of breathlessness on exertion (see appendix page 140). This has proved a very useful tool in many survey and studies, and formed the basis of Burns and Howells categories for comparing disproportionately breathless patients with others (87). However, to measure dyspnoea in different clinical situations, for example following exercise, scales are required that provide a rating for the immediate sensation experienced at the time. Two types of scale are widely used; the visual analogue scale, and Borg's rating of somatic stress, the 'perceived exertion' scale (88).

Aitken described the use of a 100 mm visual analogue scale to study various feelings including depression and anxiety, in addition to the assessment of dyspnoea (89). He studied subjects breathing through respiratory resistances and found a rectilinear relationship between dyspnoea and the logarithm of the resistance of the valve (90). The usual procedure is to allow patients to experience the stress of maximum exercise first by use of a maximum exercise test to 'anchor' one extreme end of the scale, usually designated 'very breathless' or the 'most breathless I have ever been', with "not at all breathless" at the other end of the scale. Using this method Stark and Gambles, and Guz were able to show a high degree of within subject reproducibility following both exercise and carbon dioxide rebreathing in normal subjects (91, 92). Stark and Gambles also demonstrated reproducibility in patients with airflow obstruction and the sensitivity of visual analogue scales in detecting the effect of Salbutamol on breathlessness during exercise. The VAS seems to be particularly useful for frequent monitoring of breathlessness e.g. during an exercise study. Adam and Guz compared their use of the VAS with a 'magnitude estimation' technique (92). Here patients were instructed to attach a certain number e.g. '10' to dyspnoea produced by moderate exercise, and estimate greater or less dyspnoea subsequently by multiplying or dividing the original value. The advantage of this technique is that it is proportional and not fixed by defined limits like the VAS. However, this is also a disadvantage as it is not linear and analysis is much more complex.

The VAS has been used in a number of studies to detect changes in dyspnoea produced by drugs or oxygen. Promethazine, not diazepam, was shown by Woodcock to reduce dyspnoea on exercise (68) although a previous study had suggested diazepam may reduce dyspnoea in larger doses when given to emphysematous patients (93).

A further study by Woodcock examined breathlessness and exercise tolerance following oxygen treatment before or during six minute walks, measuring breathlessness with a visual analogue scale (71). Oxygen given during exercise both increased exercise tolerance and decreased breathlessness.

Thus the visual analogue scale has become accepted as a useful tool in the evaluation of breathlessness in experimental situations, and in the effect of drug treatment. Borg's scale provides a different approach, measuring the concept of effort and 'hardness' of exertion, which includes breathlessness, fatigue and stress. The scale consists of 15 grades from 6-20 giving the 'RPE' values, or 'ratings of perceived exertion'. (Appendix page 139).

Borg's scale has been used in a number of studies of exercise and perceived exertion in normal and chronic bronchitic subjects. The RPE score correlated well with oxygen uptake and ventilation (94, 50). McGavin found close negative correlation between the 12 MD and RPE in patients with chronic bronchitis, indicating that those who walked least far found the test the hardest (59).

In conclusion, visual analogue scales show little within subject but great intersubject variability. They have the advantage of much easier visual display, e.g. on screen monitor, and are thus easily adapted for use in dynamic experiments stimulating 'dyspnoea' by exercise, hypercapnia or hypoxia, where the dyspnoea felt may be monitored continuously. Borg's scale of perceived exertion would be difficult to use in these circumstances, and the visual analogue scales appear superior. I have used Borg's scale in this study so patients can rate their overall perception of the 'hardness' of exercise as it seemed likely that the limiting factor in self-paced exercise may include a range of symptoms that together constitute effort and fatigue, rather than breathlessness alone.

1(7) PSYCHOLOGICAL ASPECTS OF BREATHLESSNESS IN LUNG DISEASE

Despite these advances in the understanding of dyspnoea, its measurement remains imprecise and subjective. In respiratory disease, assessing the disability of patients from their breathlessness is also necessarily imprecise. Clearly the state of mind and state of arousal are very important. However, to study the effects of psychological influences on a symptom related most directly to an organic disease like emphysema is difficult. This section of the literature review first of all examines some early papers drawing attention to the importance of psychological factors in respiratory disease. The overlap and confusion surrounding 'hyperventilation syndrome' is then discussed, and lastly I review some more recent studies of psychological factors in asthma and chronic bronchitis.

1(8) EMOTIONAL ASPECTS OF RESPIRATION, HYPERVENTILATION SYNDROME AND BREATHING PATTERNS

Charles Darwin in 1855 wrote "men during numberless generations have endeavoured to escape from their enemies by headlong flight .... such exertion will have caused the heart to beat rapidly and the breathing to be hurried, and the chest to heave .... and now whenever the emotion of fear is strongly felt though it may not lead to exertion, the same results reappear through inheritance and association" (95).

Thus Darwin recognised the pattern of breathing and heart rate induced by heightened emotion and linked it to an inherited instinct to flee. This altered pattern of breathing seen in states of emotional arousal was described in 1916 by Felecky who studied spirographic recordings in normal subjects during various degrees of emotional arousal, and noted abnormalities of a rate, depth, and rhythm appearing with increasing states of arousal (96). In 1935 R V Christie studied patients with anxiety neurosis and hysterical conversion neurosis, finding the major abnormality in the anxious patients was irregularity in the functional residual capacity and hence the vital capacity, with less marked irregularity in rate. In patients with hysteria the predominant problem was a symptom of "oppression and suffocation" causing the breathing pattern to show paroxysms of deep rapid breathing of such severity to create a respiratory alkalosis (97). Similar abnormalities in the spirogram of anxious patients were also described by J S Haldane in 1935 (98). The patients described were interesting for their background - they were largely soldiers returning from World War 1 complaining of a variety of symptoms that we would now relate to anxiety, although thought possibly to have 'chronic gas poisoning'. Other labels such as 'soldiers heart', or 'neurasthenia' had been applied. Their breathing pattern also showed irregularity in depth and timing and occasional deep sighs. Other earlier descriptions of similar findings can be attributed to Finesigner, and Davis, who also studied repatriated prisoners of war this time from World War II (99, 100, 101).

What to call a condition where disturbances of respiratory pattern are related to symptoms of breathlessness, often associated with aches and pains in the chest and tachycardias, where no organic abnormality is found is not so important, as long as it is recognised clinically. Kerr called it 'hyperventilation syndrome', and this term has survived the longest and created much controversy (102).

Hyperventilation itself is a precise term indicating hypocapnia (low resting carbon dioxide tension) and this may not be present at all times in patients. In Lum's large series of 2000 cases hypocapnia was only found in a third of his cases and the author felt that it was fluctuations in arterial carbon dioxide tension that led to many of the symptoms rather than sustained hypocapnia (103).

Interest in breathing patterns has recently been rekindled by the availability of non invasive techniques of monitoring chest and abdominal wall movement during breathing, using both the respiratory inductive plethysmograph or magnetometers (104). Gribben has recently studied nine naive normal subjects with abdominal wall magnetometers, who were asked to breathe normally in sitting and lying positions (105). A large intersubject variability in breathing pattern was seen, and all subjects showed clearly defined periodicity, with apnoes up to 15 seconds long being recorded. Monitoring arterial carbon dioxide tension by transcutaneous electrodes, changes of 6-10 mm Hg were seen. Thus great caution is needed when relying on breathing patterns alone to diagnosis hyperventilation syndrome - normal subjects can also show marked variability. There is no objective test for hyperventilation syndrome; recognition of the complex of symptoms together with observation of respiratory patterns are most important.

Caution is also required where organic disease may be present. First of all, some organic diseases cause hyperventilation. Asthma, pulmonary emboli and parenchymal lung disease can all cause hyperventilation (106, 107, 108).

In a recent study of 21 patients with hyperventilation syndrome and hypocapnia, lung function tests were normal. However bronchial hyperreactivity suggesting asthma was present in two, and ventilation and perfusion scans showed unmatched defects suggesting pumlonary emboli were present in three of the fifteen tested (109).

My own feeling about 'hyperventilation syndrome' is that it is rare as a sole entity and I feel that this is where the controversy starts. Patients whose only symptoms are respiratory should be investigated thoroughly in case asthma, pulmonary emboli or emphysema are present. If others labelled as having 'hyperventilation syndrome' are assessed psychiatrically, no doubt other features of anxiety or neurosis would emerge in many, and the correct diagnosis should be 'anxiety state' with perhaps 'psychogenic dyspnoea'. In other words, I do not think that 'hyperventilation syndrome' is nearly as common as Lum and others have suggested. On the other hand I do feel that it is important that physicians should recognise that in many patients with definite organic lung disease, particularly asthma and emphysema, anxiety is common and may magnify the sensation of breathlessness, and alter patients breathing patterns.

1(9) PSYCHOLOGICAL FACTORS IN ASTHMA

So far I have followed the early recognition of the link between emotion and breathing, through to the discussion of 'hyperventilation syndrome', and now to a grey area where slight organic defects may be found in patients with predominantly psychological symptoms, and features of a neurotic disorder. However, what of the role of psychological factors in actual organic lung disease? Considerably less has been written about psychological factors in lung disease than about 'hyperventilation syndrome'. Whilst for most lung diseases this may reflect merely its unimportance, for conditions presenting principally with breathlessness, e.g. asthma and emphysema, it seems surprising.

Interestingly, tuberculosis was the first respiratory illness considered to have a psychological dimension, so much so that in 1929 a meeting between psychologists and chest physicians was convened in Ohio to discuss the role of 'emotion' and TB. Generally emotional upset and depression was considered to delay recovery from tuberculosis in sanatoria, and was considered common in TB sufferers in general (110, 111).

Emotional factors in asthma have long been recognised and indeed have probably been over emphasised in the past (112). However a number of studies have laid emphasis to the prevalence of psychological symptoms amongst asthma sufferers without seeking to attribute a causal role to them.

In a thoughtful review of his own practice, Gillespie described many patients where he considered there were clear psychological factors influencing the cause of their disease (113). Patients where these factors were important tended to be anxious, over sensitive, and often experienced worsening of their asthma when personal or marital relationships broke down. In some, loss of self esteem through failures at work or marriage often preceded a deterioration in their asthma. Although not a formal study, this paper describes cases which no doubt would appear familiar to any physician dealing with many cases of asthma. A large controlled study carried out in Cardiff compared personality traits, psychiatric symptomatology and life events in asthmatic patients and controls who were hospital patients recovering from simple surgery (114). While no specific personality types were found associated with asthma there was a significantly higher incidence in asthmatic subjects of over-anxiety, timidity, over-sensitiveness and marked obsessional traits.

A careful study conducted in Edinburgh measured the degree of psychopathology in a randomly selected group of asthmatic patients and compared them with two sets of controls, age and sex matched 'normals' and 'neurotics' (115). Sixty-eight asthmatic subjects were selected from an asthma register and matched with normal or neurotic controls. With the exception of a smaller group of 14 asthmatic patients referred by psychiatrists, there was no evidence that asthmatics differed from the normal population in the amount of psychiatric symptomatology detected. No relation was found between the amount of psychopathology and the severity of asthma. It seemed therefore that psychopathology could not be implicated in the cause of the asthma, rather that concomitant psychopathology may determine its clinical presentation.

One feature noted from an earlier part of this study was that given a small inspiratory resistive load, the response of the asthmatic was to hyperventilate compared to the normal or neurotic controls (116).

Hyperventilation, in addition to causing the symptoms discussed earlier may also induce further bronchoconstriction in asthmatics, particularly if they breathe cold air (117).

The idea that suggestion may play a role in asthma was explored by Luparello who demonstrated that inhalation of saline produced bronchoconstriction in a patient who thinks he is receiving a specific allergen (118). This has recently been taken up again by Neild and Cameron who showed that bronchoconstriction can occur in asthmatics when given nebulized normal saline with the suggestion that this is a bronchoconstrictor (119), agreeing with two further American studies (120, 121).

Thus in summary, whilst asthmatic patients may suffer traits of anxiety, sensitivity and lack of self-confidence, perhaps as a consequence of their disease, there is no good evidence that pre-morbid personality characteristics make asthma a 'psychosomatic disease'. However, neurotic symptoms may occur amongst asthmatics like many other people, and when they do they may adversely affect the pattern of the patients asthma. As Aitken showed in the follow up to his study, psychiatrists' treatment of anxiety neurosis found in asthmatic patients may also improve their asthma (115).

Whilst the volume of literature on psychological aspects of asthma is considerable and not reviewed here, psychological factors in chronic bronchitis have not been studied extensively, considering the size and economic importance of the problem.

1(10) PSYCHOLOGICAL ASPECTS OF CHRONIC BRONCHITIS

Undoubtedly the first most important study of psychological aspects of chronic bronchitis was carried out by Burns and Howell, published in 1969 (87). Earlier Capel and Smart in 1959 had laid down approximate guidelines for the degree of disability to be expected for patients with an FEV1 of greater than one litre - that is that they should be able to walk slowly on the level for a mile, but not able to be able to keep up with others without breathlessness (24). Using this approximate guide and their own experience, Burns and Howell studied thirty one bronchitic patients whose breathlessness was considered disproportionate to their clinical state. They compared the clinical, physiological and psychiatric findings in this group with a control group of thirty one chronic bronchitic patients whose breathlessness was considered appropriate to the measured ventilatory impairment. The psychological examination was principally concerned with evidence of hyperventilation, life crises within the preceding three years, psychiatric symptomatology and ratings of personality traits. The findings of this study were that the group labelled 'disproportionately' breathless had a shorter history of breathlessness, significantly better pulmonary function, and nearly all had symptoms which could be included in a diagnosis of 'hyperventilation syndrome' as well as chronic bronchitis. All were found to have a classifiable psychiatric disorder, most commonly a depressive illness, with others demonstrating an anxiety or hysterical reaction. Those considered disproportionately breathless indicated certain features of their breathlessness not common the control group (see Table 3).

Table 3. Symptoms Associated with Disproportionate Breathlessness (Burns and Howell, 1969)

1. Poor relationship between breathlessness and exertion

2. Breathlessness at rest

3. Acute hyperventilation attacks present

4. Difficulty in breathing - getting air in to the lungs

5. Fear of sudden death during attacks

6. Breathlessness not improved by periods of stopping smoking

7. Breathlessness relieved by sedatives or alcohol

8. Breathlessness not relieved by bringing up sputum.

Thus there was a poor relationship between breathlessness and exertion, acute hyperventilation attacks were present, and the chief difficulty was in getting air into the lungs rather than out. Personality traits commoner in the disproportionate breathless group were of anxiety, obsessional traits, hysterical features, and lifelong excessive health consciousness. Patients with either a depressive illness or an anxiety state were treated and followed up for a year. Most noted improvement not only in their psychiatric state, but also their breathlessness and exercise tolerance. Those with hysterical features did less well - only two out of eight improved.

This study was important and has probably inspired a number of subsequent studies, including the work for this thesis. The main problem in using the information gained for the management of the breathless bronchitic patient is the extreme nature of Burns and Howell's disproportionately breathless group. The fact that all had an identifiable psychiatric syndrome suggests that they had two conditions, i.e. a psychiatric one, with manifestations of hyperventilation syndrome and chronic bronchitis. Their selection for study provides interesting findings, but they may represent, from the physicians view, only a small proportion of cases encountered in practice. A recent study of psychotherapy in rehabilitation of (psychiatrically) unselected disabled bronchitic patients did not show improvement in those thought to have psychiatric disturbance, suggesting that the psychiatric disorder may have been secondary to the severe physical disease, unlike Burns and Howells' group (122).

Further studies of psychiatric morbidity and chronic bronchitis have been carried out since Burns and Howell. Faulkner studied fifty two patients with chronic bronchitis and found that 19/52 (37%) were psychiatrically disturbed using standard psychiatric interviews (123). This compares with 60% of patients studied by Rosser (122), and 48% in a study by Rutter (124). Rutter studied thirty chronic bronchitic patients with age and sex matched controls using the General Health Questionnaire (GHQ), also used by Rosser, and found psychiatric disturbance in 48% of patients of 11% of controls.

Patients also scored more highly on scores of 'neuroticism' and 'depression' than the control group. In an earlier study Oswald found not only that a group of bronchitic patients appeared to score more highly on scales of neuroticism than asthmatics and controls, but also that the scores of neuroticism increased with increasing breathlessness and decreasing pulmonary function (125). The asthmatics in Oswald's group lay in an intermediate position of neuroticism between the bronchitics and their normal controls.

All these studies used the Eysenck Personality Inventory (EPI). Oswald and Rosser compared their results with previously measured 'normals' from other studies. The scale of extroversion measures a subject's tendency to be outgoing, uninhibited and gregarious; introversion the opposite. No significant differences were found amongst the bronchitic population, although Oswald noted a trend towards introversion. However in a study not directly concerned with the psychological features of the disease, Clark and Cochrane studied the alveolar carbon dioxide tension in 44 patients with bronchitis and emphysema, and demonstrated an inverse relationship between carbon dioxide levels and scores for extroversion on the EPI (127).

This study lent some support to the clinical impression described by Dornhurst dividing bronchitic patients into two groups: 'the pink puffers' and 'blue bloaters' discussed earlier (32). The idea that pre-morbid personality characteristics may influence the pattern of a disease like chronic bronchitis to the extent that different patterns of presentation could emerge seems however very unlikely in view of the lack of evidence that the range of the characteristics measured can not be shown to be different from control populations.

Rutter continued her study of bronchitic patients by following 83 patients over a year assigned to three management regimes to assess which factors could predict outcome, assessed in terms of lung function, time of work, symptoms and death (128). The management regimes differ by the frequency of follow up over a year's period and the addition of physiotherapy. No differences were found between any of the regimes. However psychological variables were found to have prognostic significance not only for days lost from work, but also medical measures of illness severity.

From this larger study, Rutter made use of the semantic differential technique (discussed in detail later) where attitudes and beliefs of patients are measured and used in correlative and factor analysis. The advantage is that commonplace ideas about illness, treatment, and symptoms can be presented to the patient for whom psychological and personality questionnaires may well be unfamiliar and prove daunting.

In conclusion, since the later 1960's interest has been increasing in the psychological aspects of chronic bronchitis, and their importance in influencing the many symptoms which ultimately lead to chronic respiratory disability. Whilst most studies agree on the high incidence of psychiatric illness in the bronchitic population there remains much controversy about the role of psychiatric treatment in rehabilitation. None of the studies have examined in detail the effect of psychological factors and psychiatric morbidity on exercise tolerance - the subject of this thesis.

CHAPTER 2

Study 1 PHYSIOLOGICAL AND PSYCHOLOGICAL FACTORS AFFECTING THE 12 MD

2(1) INTRODUCTION

In order to test the hypothesis that psychological factors may affect exercise tolerance in chronic bronchitis (Figure 1) this study relates a series of psychological factors from standard questionnaires to exercise tolerance reflected by the 12 MD. Ventilatory capacity and arterial $Pa0_2$ and $PaCO_2$ are also measured and comparisons made of the relative predictive value of the physiological and psychological variables on the distance walked.

2(2) PROTOCOL

Measurement of ventilatory capacity and arterial blood gases were completed before exercise. Two 12 minute walks were then completed, each followed by estimation of 'perceived exertion'. Lastly, psychological questionnaires were administered. Thus:

Measurement of impairment (FEV_1, FVC, $Pa0_2$, $PaCO_2$)

↓

12 MD x 2

↓

'RPE'

↓

Psychological assessment (mood, general psychiatric health, attitudes and beliefs of patients)

2(3) AIMS OF THE PSYCHOLOGICAL ASSESSMENT

The aims of the psychological assessment were to detect psychological factors which may be relevant to disability in an older physically disabled population. Both the gathering of data and its analysis were carried out by the author, who had no training in clinical psychology or psychiatry. An interview was ruled out mainly because of this, and also because this carries an inherent element of observer bias.

Ideally, interviews in psychosomatic research should be carried out by two interviewers to avoid bias and this would have been logistically difficult (129). Data from standard questionnaires may be criticised for their validity and reproducibility, but generally yield data more easily analysed statistically than the data from standardized interviews. In general, standardized and previously validated questionnaires were used to yield factors which could be easily understood by a general medical audience. These are described in the next chapter and have been selected and designed to detect both psychiatric disturbance and other psychological factors thought to be relevant in what is primarily a 'non-psychiatric' group of patients. Attitudes and beliefs of the patients towards their illness were measured as it was thought that learned concepts and notions may well be as important in their influence as more overt psychiatric disturbance.

2(4) PATIENTS STUDIED

The patients studied were recruited sequentially from general respiratory clinics, both at the Royal Victoria Dispensary in Edinburgh and from outpatient respiratory clinics at the City Hospital, Edinburgh. They were under the care of Dr G J R McHardy, Professor D C Flenley and Dr Michael Sudlow, who had kindly given me permission to study their patients. The patients were selected on the following grounds:

1. Satisfy British Medical Research Council criteria for diagnosis of chronic bronchitis.

2. Significant airflow obstruction with no reversibility to inhaled B_2 agonist.

3. Age less than 70 years.

4. No clinically detectable or cardiac disease other than controlled 'cor pulmonale' which could influence exercise tolerance.

5. No locomotor or orthopaedic disorder which might decrease exercise tolerance.

6. No peripheral vascular disease.

7. No known psychiatric disease and not currently taking psychotropic drugs.

The study groups were selected on the grounds that they were essentially 'normal' individuals with chronic bronchitis and were not thought to be psychiatrically unstable or indeed be suffering from 'disproportionate' breathlessness by their physician.

Each study itself took approximately half a day to complete, which often demanded a day's attendance from the patients, including travelling time. Patients were studied when clinically stable, i.e. no current infective exacerbation. Some were hospital inpatients who had recovered from such an exacerbation prior to their discharge home, and were studied while still in hospital.

CHAPTER 3

METHODS OF STUDY

3(1) DOCUMENTATION

Patients were recruited consecutively from the respiratory clinic as described. They satisfied the M.R.C. criteria from chronic bronchitis, i.e. chronic cough and sputum production for at least 3 consecutive months for more than 2 successive years (4). They were then asked to grade their breathlessness to the M.R.C. criteria (Appendix Section I, Page 140).

3(2) MEASUREMENT OF VENTILATORY CAPACITY

Two previous studies in our laboratory have confirmed that vital capacity bears a significant relationship to exercise tolerance, measured by the 12 MD in bronchitis patients (26, 54). For this study ventilatory capacity measured by spirometry was used as the measurement of pulmonary function. Forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) were measured on a low-resistance spirometer (130) and the best of 3 readings were taken (131),

3(3) ARTERIAL BLOOD GASES

Arterial blood was sampled from the radial artery following local anaesthesia with 1% lignocaine. Analysis was by Radiometer electrodes. Where patients were inpatients, either for assessment or following recovery from recent acute illness, arterial blood gas taken within 2 days of the study day were used in the analysis, provided they were taken when the FEV_1 and FVC were unchanged.

3(4) THE TWELVE MINUTE WALKING DISTANCE (12 M.D.)

Exercise tolerance was measured by the self paced 12 MD. The test was carried out on a long level hospital corridor at the City Hospital, Edinburgh, and patients were instructed as in the appendix (page 140). Encouragement to cover as much ground as possible was given just prior to the walk, but no encouragement was given during the walk (58).

Two walks were performed with at least twenty minutes rest between each, the longer distance being used in the analysis. Following each walk the patients estimated their severity of effort using Borg's scale.

3(5) PERCEIVED EXERTION (PE) (Appendix page 139)

As has been previously discussed Borg's scale provides a means by which patients estimate the severity of their effort by indicating a number between six and 19, positioned by a verbal description of effort. The rate (RPE) from the longest walk was used in the analysis.

3(6) PSYCHOLOGICAL ASSESSMENT

The series of psychological assessments made on patients were chosen for their simplicity for patients, as well as for the subsequent ease of analysis by non-psychologically trained investigators. Essentially an overall measurement of whether the patient was in a general way upset psychologically was made using the General Health Questionnaire ("GHQ"), followed by a measure of mood disturbance, depression, anxiety and hostility using the Multiple Affect Adjective Check List (MAACL).

Following this the patients' attitudes and beliefs towards themselves, their families and their illness were assessed by the semantic differential. The details of these questionnaires follow and are set out in full in the Appendix. Most patients were able to complete all the questionnaires in one hour. Table (4) summarises these tests.

3(7) THE GENERAL HEALTH QUESTIONNAIRE (SEE APPENDIX PAGE 141)

This is a test first developed by Goldberg in 1972 and reviewed in 1974 and 1985 (132, 133, 134). It was designed principally to detect psychiatric symptoms in those patients with physical illness. Essentially, as can be seen from the questions asked, it asks the patient to say whether or not a symptom has been experienced "more than usual", rather than asking patients whether a particular symptom is present or not. It therefore measures the degree of psychiatric illness related to changing physical illness and as such is valuable for assessing non-psychiatrically orientated patients complaining of increasing disability.

A patients' score in the GHQ is in many ways analogous to the erythrocyte sedimentation rate (ESR) in general medicine. A high score merely indicates that there is probably something wrong - it does not reveal the diagnosis.

In this study the shorter 30 item version of the GHQ was chosen. This loses little of the longer 60 item versions' correlation with clinical status ($r = 0.7$ for 30 item test, $r= 0.8$ for 60 item test) (133).

Tabel 4 Psychological Questionnaires

Questionnaire	Function
General Health Questionnaire (GHQ)	Detection of psychiatric symptoms
Multiple Affect Adjectives Check List (MAACL)	Mood disturbance
'Semantic Differential'	Attitudes and beliefs

3(8) EXAMINATION OF MOOD - MULTIPLE AFFECT ADJECTIVE CHECK LIST (MAACL) (SEE APPENDIX, PAGE 146)

This 132 item check item is designed to measure anxiety, depression and hostility at the time of performing the test and hence is very useful in judging mood disturbance during a study, i.e. in this study just prior to an exercise test (135). It is also simple to administer and score, and no patients experienced difficulty in understanding its use.

Its sensitivity to transient changes in mood state, which is important when relating the effect of mood to clinical investigations like exercise tests, has been well investigated. Examples of previous use are in the prediction of pain responses in rehabilitation (136), measurement of examination related anxiety (137) and stress during combat training in military recruits (138).

For the patients, completing the check list means indicating all the adjectives of the list of 120 which describe how they feel at the time of the test. The check list is laid out alphabetically rather than by mood category. However, for scoring reference is made to Table 5 showing the key words rearranged under each mood category. From the key it can be seen that some words when indicated score positively and other when not responded to, also score towards the total, i.e. ticking 'afraid' scores a point for the total of 'anxiety' score, not indicating 'calm', also scores a point for the 'anxiety' score.

Table 5

KEY WORDS FOR MULTIPLE AFFECT CHECK LIST [+ = indicated, - = not indicated]

Anxiety		Depression		Hostility	
+	-	+	-	+	-
afraid	calm	alone	active	angry	agreeable
desperate	cheerful	awful	alive	bitter	amiable
fearful	contented	blue	clean	cruel	cooperative
frightened	happy	destroyed	enthusiastic	disagreeable	friendly
nervous	joyful	discouraged	fine	discontented	good-natured
panicky	loving	forlorn	fit	disgusted	kindly
shaky	pleasant	gloomy	free	enraged	polite
tense	secure	hopeless	gay	furious	sympathetic
terrified	steady	lonely	glad	irritated	tame
upset	thoughtful	lost	good	mad	tender
worrying		low	healthy	mean	understanding
		miserable	inspired	offended	willful
		rejected	interested	outraged	devoted
		sad	lucky	stormy	warm
		suffering	merry	unsociable	
		sunk	peaceful	vexed	
		terrible	safe		
		tormented	strong		
		unhappy	whole		

3(9) SEMANTIC DIFFERENTIAL

This is a technique developed by Osgood, and designed to measure the various different attitudes and beliefs that a person may hold towards certain concepts (138). Familiar to those working in applied clinical psychology, it has been little used by physicians investigating the problems of the physically ill. The concepts and their scales used in this study have been adapted from those used by Rutter, who first used them in bronchitic patients (see Appendix page 148)) (128). examples of the concepts are 'my bronchitis can be improved', 'my bronchitis is a long term condition', 'physical exercise is good for me'.

Below such concepts are a number of seven point scales set between adjectives of opposite meanings, e.g. impossible-possible, likely-unlikely, true-false. Thus the patients are asked to rate these concepts by indicating their feeling of attitude or belief on the seven point scales, and then score from a scale of 1-7, used in the analysis of that particular factor.

Two main problems arise with the semantic differential: firstly its reproducibility and stability: secondly whether or not what is measured actually has a valid meaning.

Norman studied the reproducibility of the semantic differential when 30 subjects rated a set of 20 concepts on two occasions over a month (139). Reproducibility was analysed in terms of the percentage of the maximum number of points that could be changed from the initial scores e.g. the greatest change that an initial score of '1' could show would be at the other end of the scale, - a change of '6'. Changes from initial scores of two could only change by a maximum of five. From this, over a month, 40% of scores were unchanged, 35% changed by '1', and 25% by 2 or more. The average change was only 1.07. Only a slight difference was seen between the different concepts, with a range of average changes from 0.92-1.28. Rutter also studied the stability characteristics by comparing the mean scores of each scale and found that no significant changes occurred across a period of one week (140).

Stability over shorter periods were studied by Fishbein who found over a four day period correlations of 0.9 between scores of forty-three subjects (141). Osgood found a shorter term shift of 0.67 for individual scales over a thirty minute interval.

Whether the responses to the individual scales actually reveal attitudes was investigated by Marks who compared responses from the semantic differential with independently assessed attitudes and beliefs by interviews with psychiatrists, and found a high level of agreement (142). Fishbein tested scales of responses toward extra-sensory perception (ESP) by four groups told to hold different ideas and attitudes towards ESP. The semantic differential subsequently clearly distinguished the four groups (141).

Such a technique can never hold the precision and reproducibility of a physiological measurement and can easily be criticised for this. However the semantic differential has been found useful in many studies, and when applied to clinical medicine, it allows us to examine and even quantify feelings by patients and therefore gain an insight into the impact of a disease, its treatment, and its effect on the individual.

3(10) ANALYSIS

Statistical analysis was by hand and computers (143, 144). Correlation (product moment) and multiple regression analysis were computed using the SCSS programme. The multiple regression analysis incorporated automatic elimination of highly intercorrelated variables so only those with independent significant contributions to be variance were retained. Analysis of variance where appropriate was by computer. 't' tests for comparisons between means were by hand. Significance levels where appropriate were obtained from published tables (145).

CHAPTER 4

RESULTS - PHYSIOLOGICAL VARIABLES, SUBJECTIVE ASSESSMENT AND THE 12 MD

4(1) PATIENTS

Fifty patients (38 men, 12 women) took part in the study. Their ages ranged from 42-70 years (mean 60.5 + 6.8 years). All had chronic bronchitis according to the MRC criteria. 27 men were still smoking cigarattes at the time of the study, but only six women. However all had been heavy smokers of at least 40 pack years.

4(2) VENTILATORY CAPACITY

A wide range of ventilatory impairment was represented by the group studied: FEV1 ranged from 0.25 to 3.5 litres BTPS (mean 0.97 ± 0.6 litres); FVC from 1.1 to 5.2 litres (mean 2.59 ± 0.96 litres). See Appendix page 163 - for individual results and Figure 2.

4(3) WALKING DISTANCE (12 MD)

The distance walked in twelve minutes also revealed a wide range of disability, from 205 to 1460 metres (mean 794 ± 290 metres). (See Appendix page 166 for individual distances).

Figure 3 shows the relationship between distance walked and ventilatory capacity. FEV_1 did not correlate significantly with 12 MD ($r = 0.26$, $p = > 0.05$), although a significant correlation was found between FVC and 12 MD ($r = 0.29$, $p = < 0.05$).

4(4) MRC GRADE

Figure 4 shows the distribution of FEV_1 FVC and MRC grades, and Figure 5 that for 12 MD and MRC grades. Only 2 patients registered their disability from these questions as mildly disabled,

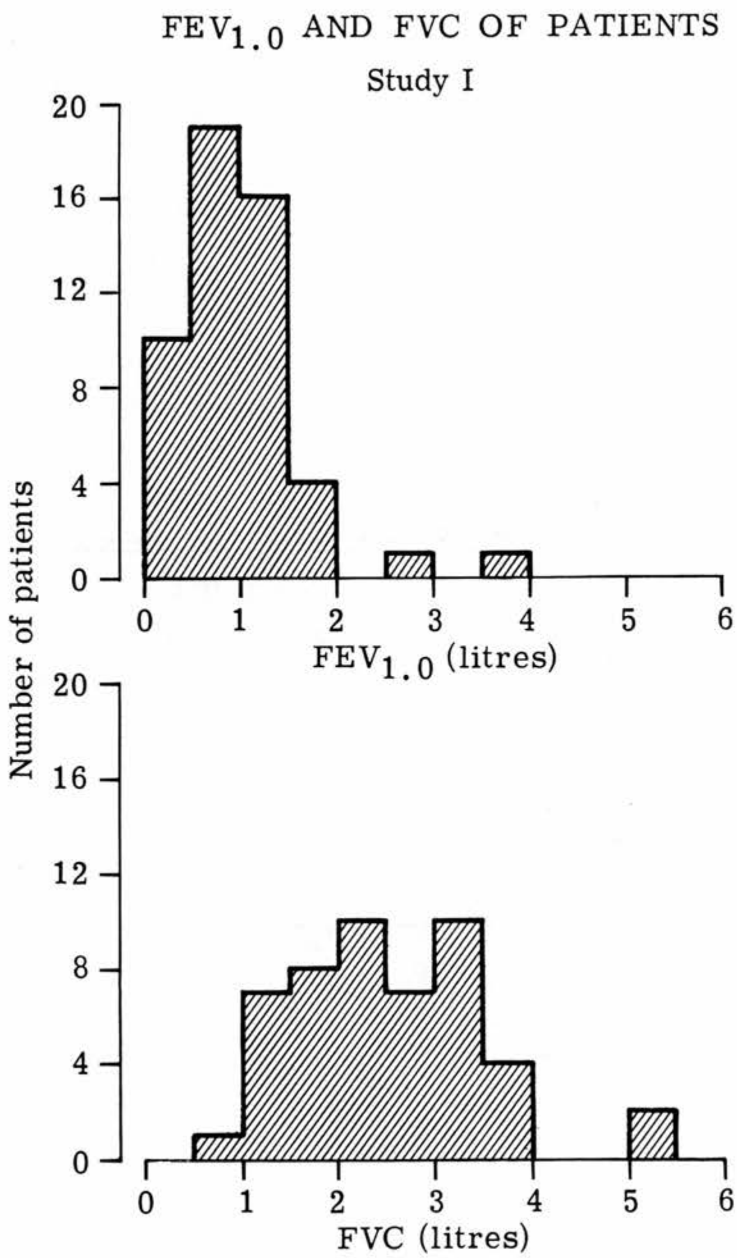

FEV1.0 AND FVC OF PATIENTS
Study I
Number of patients
20
16
12
8
4
0
0
1
2
3
4
5
6
FEV1.0 (litres)
20
16
12
8
4
0
0
1
2
3
4
5
6
FVC (litres)

Figure 2

RELATIONSHIP BETWEEN DISTANCE WALKED (12 MD)
AND VENTILATING CAPACITY ($FEV_{1.0}$, FVC)

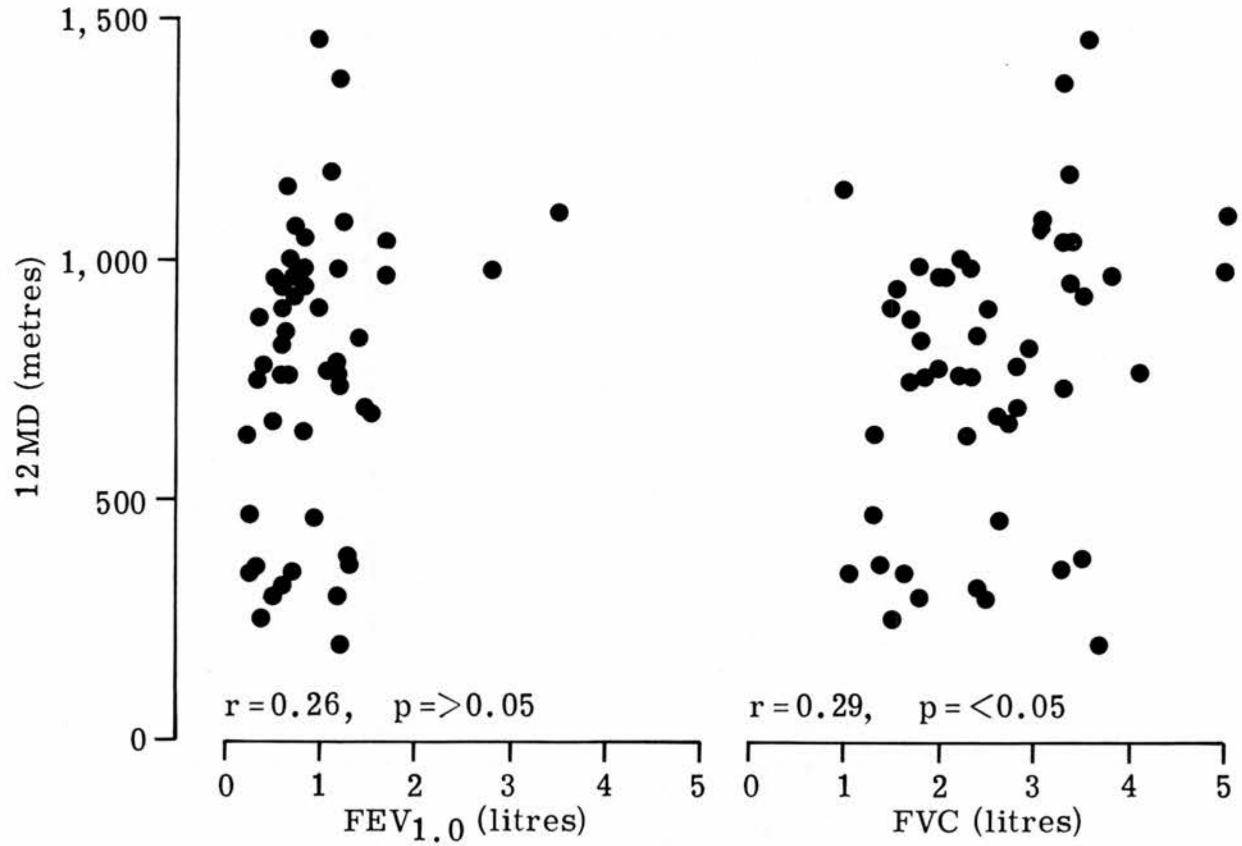


Figure 3

DISTRIBUTION OF $FEV_{1.0}$, FVC AND MRC GRADES FOR 50 PATIENTS WITH CHRONIC BRONCHITIS

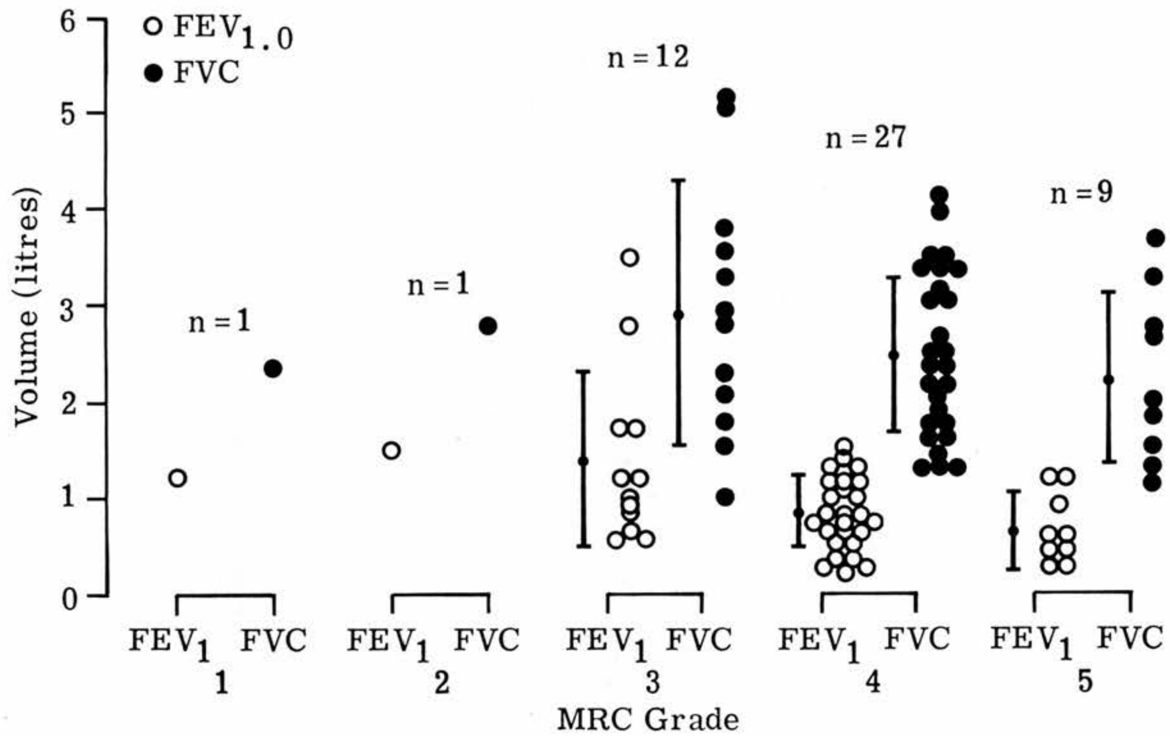


Figure 4

DISTANCE WALKED 12 MD AND MRC GRADE

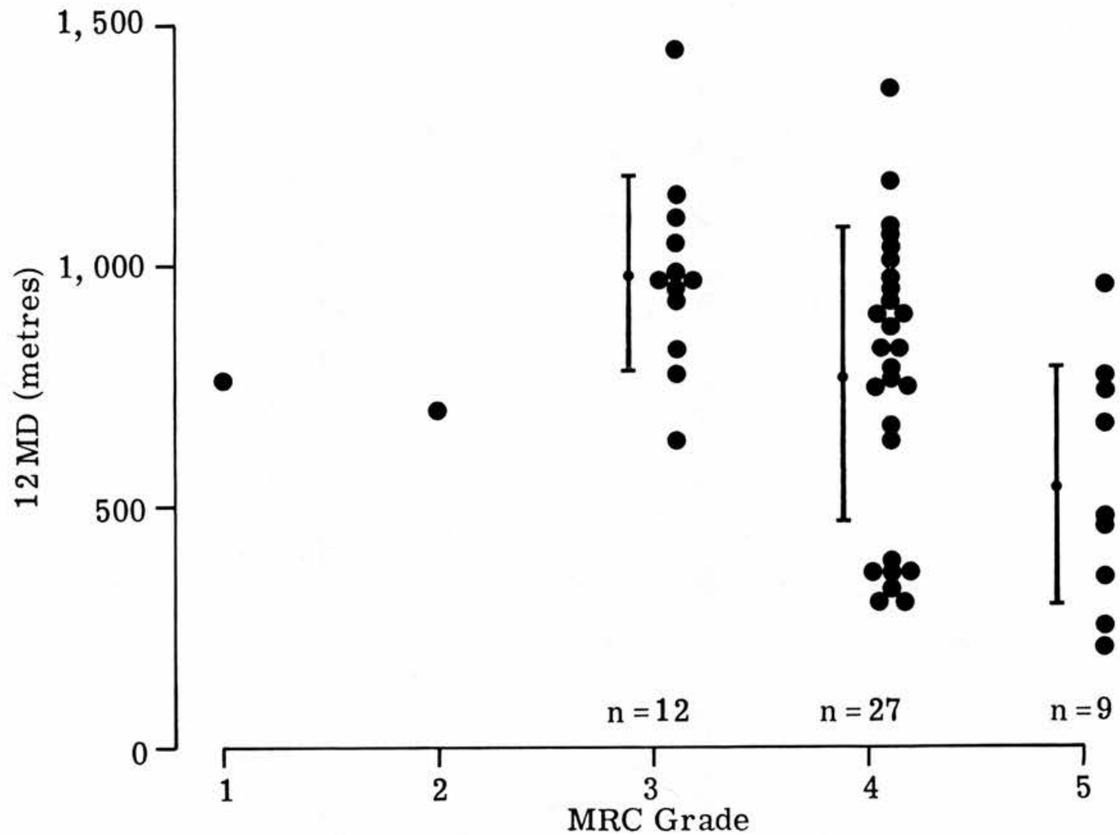


Figure 5

and the largest group graded themselves as grade IV, i.e. only able to walk 100 yards on the level. However, within this group FVC ranged from 1.34 to 4.1 litres (mean 2.47 ± 0.04) which comprised of 67% of the whole range of vital capacity measured. Patients in MRC grade IV had an FEV_1 ranging from 0.25 to 1.55 litres (40% of the whole range) and 12 MD's from 3000 to 1375 metres (93% of the range). Hence the MRC grades appear to group patients in the higher categories in spite of wide range of ventilatory capacity and walking distance, and as such can only provide a very insensitive estimate of disability.

4(5) PERCEIVED EXERTION (Figure 6)

Following the 12 MD patients rated how hard they perceived their exertion using Borg's scale (see appendix page 139). The median and modal response was '15' or 'hard' and the distribution of responses is seen in figure 4. As can be seen the responses ranged from 'light' (11) to 'very very hard' (19). A criticism could be made that patients tended to offer a numerical response adjacent to the verbal description. Notwithstanding this possible problem the rating of PE ('RPE') was significantly negatively correlated with the 12 MD ($r = 0.49$, $p = <0.001$) indicating poor performance in those who felt the exercise hardest (Figure 7). However the RPE did not relate to the degree of ventilatory impairment:

Correlation of RPE with ventilatory capacity

	r	p
FEV1	-0.08	>0.05
FVC	-0.15	>0.05

4(6) ARTERIAL BLOOD GASES (n = 48)

PaO_2 ranged from 10.4 - 6.4 kPa (mean ± SD, 8.4 ± 1.1 kPa); $PaCO_2$ ranged from 4 - 7.3 kPa (mean ± SD, 5.5 ± 0.8 kPa). See Figure 8 for individual values.

DISTRIBUTION OF RESPONSES TO BORG'S SCALE

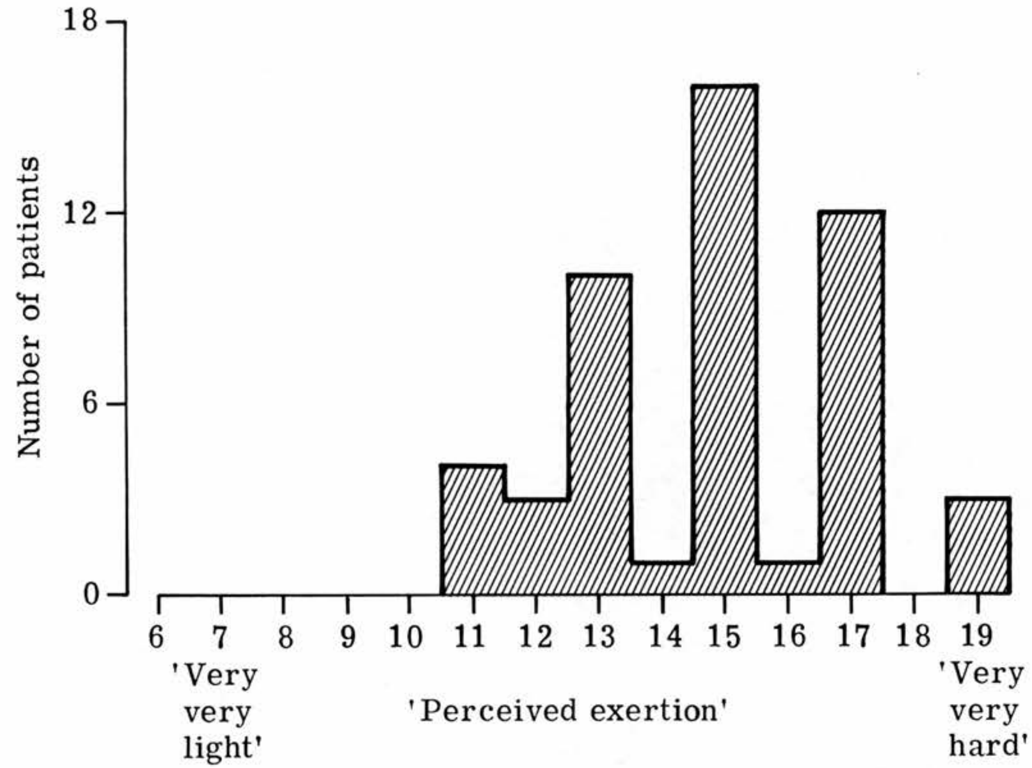


Figure 6

RELATIONSHIP BETWEEN 12 MD AND PERCEIVED EXERTION (RPE)

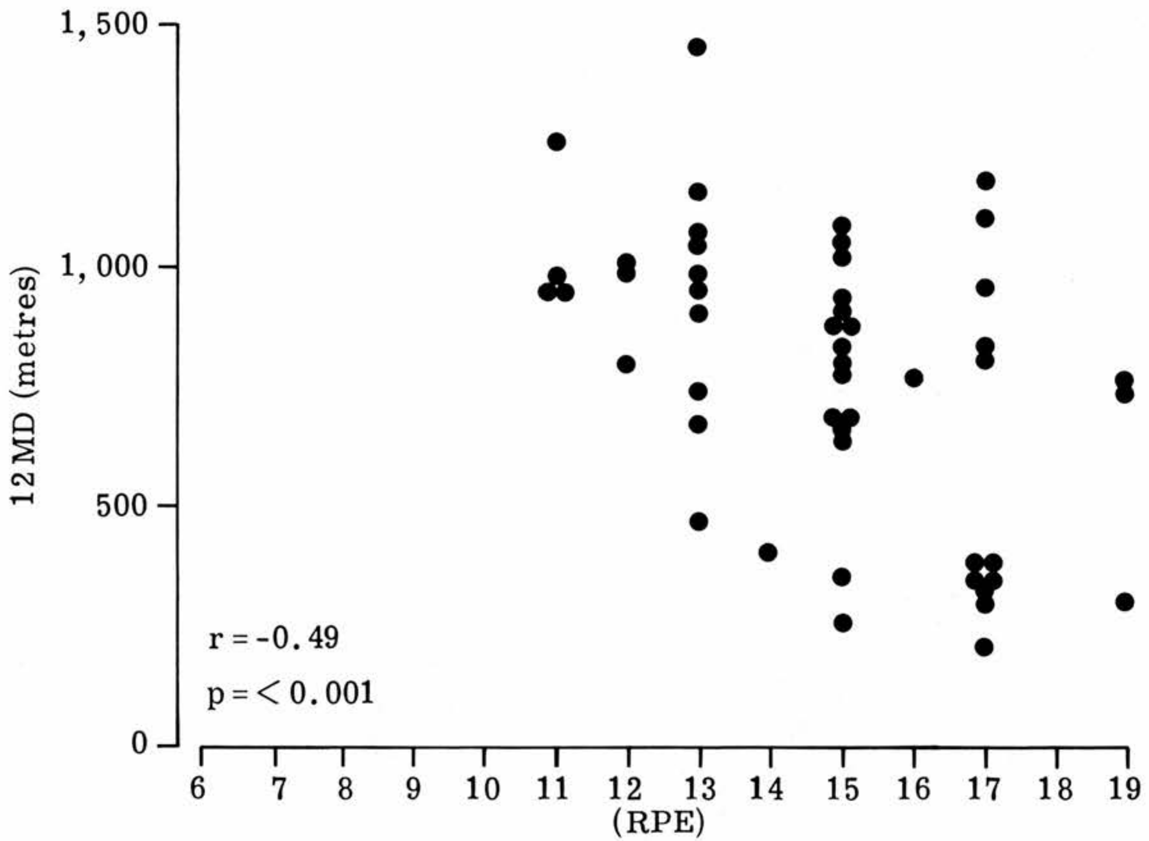


Figure 7

ARTERIAL $PaCO_2$ AND PaO_2 OF PATIENTS WITH BRONCHITIS

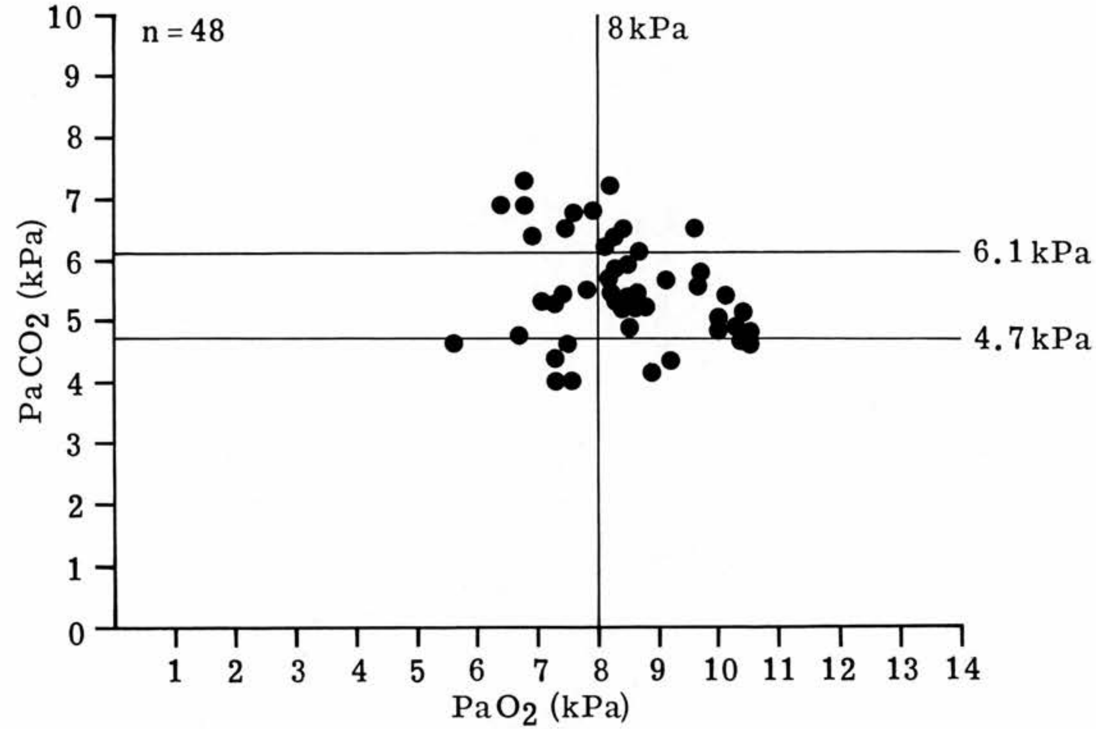


Figure 8

No significant correlations were found between PaO_2, $PaCO_2$ and the 12 MD:

	r (12 MD)
PaO_2	0.11
$PaCO_2$	0.12

<u>Subgroups</u> The individual results have been arranged into groups according to:

a) $PaCO_2$
b) PaO_2

a) $PaCO_2$ (Table 6)

The normal range for arterial $PaCO_2$ is 4.7 to 6.1 kPa (36 - 46 mm Hg) (146). I have divided patients into three groups:

1) Raised $PaCO_2 > 6.1$ kPa
2) Normal $PaCO_2 \geqslant 4.7 \leqslant 6.1$
3) Low $PaCO_2 < 4.7$

This allows identification of patients who may be hyperventilators and those with chronic hypercapnia.

b) PaO_2 (Table 7)

The patients were also divided into two groups according to PaO_2. The level of 8 kPa was chosen as the threshold below which significant hypoxia is present, principally because a paO_2 below this level constitutes an important criterion for selection of patients for domiciliary oxygen in the UK and USA (147, 148). It is also the level below which significant desaturation occurs and cyanosis becomes clinically apparent.

Table 6 Physiological variables, walking distance and perceived exertion (RPE) according to $PaCO_2$; mean ± SD

Group	n	PaO_2 (kPa)	FEV_1 (L)	FVC (L)	12 MD (m)	RPE
1 Raised $PaCO_2$ (kPa) 6.68 ± 0.35	12	7.7 ± 0.9	0.62 ± 0.35	2.03 ± 0.8	765 ± 367	14.3 ± 1.9
			*	*		
2 Normal $PaCO_2$ (kPa) 5.36 ± 0.42	29	8.84 ± 0.68	1.13 ± 0.68	2.78 ± 0.98	785 ± 283	14.5 ± 2.1
3 Low PaO_2 (kPa) 4.28 ± 0.26	7	7.62 ± 1.18	0.9 ± 0.28	2.77 ± 1.04	736 ± 297	16 ± 2.1

* = $p < 0.05$

Table 7 Physiological variables, walking distance and perceived exertion (RPE) according to PaO_2; mean ± SD

Group	n	$PaCO_2$ kPa	FEV_1 (L)	FVC (L)	12 MD (m)	'RPE'
	31					
1						
$PaO_2 \geqslant 8$ kPa		5.49 ± 0.67	1.04 ± 0.69	2.7 ± 0.69	765 ± 280	14.8
9.06 ± 0.83						
2	17					
$PaO_2 < 8$ kPa		5.6 ± 1.08	0.82 ± 1.08	2.33 ± 0.95	788 ± 3.39	14.7
7.13 ± 0.54						

From Table 6

1) The group with a high $PaCO_2$ had the smallest vital capacity.

2) The group with a low $PaCO_2$ were hypoxic (5/7 had a $Pa0_2$ of < 7.6 kPa).

3) No differences were seen in 12 MD or RPE between the groups.

From Table 7

1) Thirty-one patients had a $Pa0_2 > 8$ kPa and seventeen < 8 kPa (Table 6).

2) No significant differences in terms of FEV_1, FVC, 12 MD or RPE rating of perceived exertion) were found when patients were so divided.

4(7) SUMMARY OF RESULTS

1. A wide range of ventilatory impairment and 12 minute walking distance (12 MD) was seen in this group of patients with a considerable overlap between MRC grade, FVC and 12 MD.

2. FVC was the only physiological factor correlated with the 12 MD.

3. Perceived exertion was strongly correlated with 12 MD.

4. Examination of subgroups according to $PaCO_2$ and PaO_2 revealed no significant difference in 12 MD or RPE.

CHAPTER 5

GENERAL PSYCHIATRIC MORBIDITY AND MOOD DISTURBANCE

(1) THE GENERAL HEALTH QUESTIONNAIRE (GHQ)

The individual scores of the General Health Questionnaire are shown in the appendix (page 166). The questionnaire is scored simply by counting one point for every response in either one of the third or fourth columns responses to the questions. Hence a maximum of thirty points is possible. As previously discussed Goldberg considered a score of > 4 to indicate the presence of psychiatric symptoms, and 42 (86%) scored higher than this with a mean score of 15.3 ± 13. However, the degree of psychiatric morbidity did not relate to either the severity of ventilatory impairment or indeed performance of the 12 minute walk. Neither did the General Health Questionnaire correlate significantly with the degree of perceived exertion.

Correlation of the GHQ

	r
FEV_1	- 0.03
FVC	0.08
12 MD	0.15
RPE	- 0.12

The physiological characteristics and 12 MD of the 8 patients with scores of less than five on the GHQ are shown in Table 8. From the table, a complete spectrum of patients is represented with mean volumes similar to those for the whole group. The GHQ therefore detected a high degree of psychiatric morbidity in this group of patients, but did not appear to discriminate between them in terms of ventilatory capacity and exercise tolerance.

Table 8 Physiological variables, and walking distance in patients with low < 5 GHQ scores

Patient No	FEV_1 (L)	FVC (L)	PaO_2 (kPa)	$PaCO_2$ (kPa)	12 MD (m)
1	1.10	4.10	7.3	4.4	777.0
5	0.25	1.10	6.4	6.9	350.0
10	3.5	5.20	10.5	4.8	1110.0
20	0.62	2.20	-	-	760.0
21	0.75	3.50	8.3	5.3	923.0
30	0.75	3.05	6.7	4.8	1065.0
33	0.25	1.34	8.3	5.9	635.0
45	0.85	2.30	5.6	4.6	640.0
Mean	1.00	2.80	7.6	5.2	780.0
SD	1.00	1.40	1.6	0.9	247.8

5(2) ASSESSMENT OF MOOD BY MULTIPLE AFFECT CHECK LIST

Using the system of scoring outlined, the individual scores from scales of anxiety, depression and hostility have been correlated with physiological variables, subjective assessment, the GHQ and walking distances (see Appendix page 169 for individual results). Although the reproducibility and stability of these scales have been established, the 'normal' ranges have been based on the response of American High School students. I have therefore not used them to identify mood disturbance relying on certain threshold scores, but have used them for comparisons of correlations only. Results are in Table 9.

Thus the anxiety, depression and hostility scales did not correlate significantly with the degree of ventilatory impairment, hypoxia or hypercapnia, general psychiatric disturbance, or MRC grade. Significant negative correlations were found however with performance of the 12 MD. The high intercorrelations between scales suggest that they may be measuring a common factor, rather than that all three mood disturbances must exist together. That they may be measuring a common factor, perhaps an overall estimate of general negative affect, is supported by correlating the total score (anxiety + depression + hostility) with the GHQ which also provides a nonspecific indication of psychiatric disturbance. Adopting this approach a significant correlation may be found between a general negative affect score and the score on the General Health Questionnaire ($r = 0.41$, $p = < 0.01$).

5(3) SUMMARY OF RESULTS

1. 42 (86%) of patients demonstrated psychiatric morbidity, assessed by the General Health Questionnaire.

2. The score from the GHQ did not correlate with severity of illness (ventilatory capacity) or walking distance (12 MD).

3. Disturbance of mood assessed by scales of anxiety depression and hostility correlated inversely with the 12 MD.

4. These scales were highly intercorrelated suggesting a common factor. Addition to produce a 'negative affect' factor correlated with psychiatric disturbance measured by the GHQ.

Table 9 Correlates of Anxiety, Depression and Hostility Scores

	Anxiety	Depression	Hostility
	r	r	r
FEV1	0.04	0.04	-0.01
FVC	-0.15	-0.17	-0.12
12MD	-0.28*	-0.43**	-0.38**
Pa02	-0.04	-0.04	-0.06
PaCO2	-0.14	-0.14	-0.14
MRC	-0.05	-0.10	-0.05
GHQ	-0.04	-0.12	-0.10
Anxiety	1.00	0.85***	0.85***
Depression	0.85***	1.00	0.84***
Hostility	0.85***	0.84***	1.00

* = P < 0.050
** = p < 0.010
*** = p < 0.001

CHAPTER 6

ATTITUDES AND BELIEFS OF PATIENTS

6(1) CORRELATION BETWEEN FACTORS FROM THE SEMANTIC DIFFERENTIAL AND THE 12 MD

Of the original semantic differential of 16 concepts and 126 scales, 2 concepts and 17 scales were not used in the analysis. The concepts not used were 'my work' and 'I will be going back to work', due to the insufficient numbers of subjects actually in employment to respond to these scales. The scales were rejected where all patients responded within the same two points on the scale, usually at one extreme. Examples where this occurred are: (under the concept 'myself as I would like to be' - 'healthy - sick', 'sociable - unsociable', 'unpleasant - pleasant'). Patients all responded to the end of the scale appropriate to 'healthy', 'sociable', and 'pleasant'.

The remaining scales were correlated with the 12 MD and significant correlates are shown first in Table 10. All correlations are shown subsequently in Table 11.

The correlations make intuitive sense. The rather negative beliefs that 'treatment' might be 'dangerous' was inversely correlated with exercise performance. Optimistic belief in general positively correlated with performance, pessimistic or negative beliefs correlated inversely. Thus for example, when patients were asked to consider 'physical exercise', scores on a scale from 'bad' to 'good' correlated positively with the 12 MD, scores on a scale from 'safe' to 'dangerous' correlated inversely.

6(2) MULTIPLE REGRESSION ANALYSIS

Stepwise multiple regression analysis was then carried out on all the physiological and psychological correlates of the 12 MD. This permits identification of factors have independent effects, and removal of those that are intercorrelated. Many factors, including the scores obtained with the mood scales were eliminated. Table 12 shows the remaining factors contributing significantly to the variance in the 12 MD. The percentage variance account for by each variable is the contribution of that variable once any variable higher in the list has been accounted for.

Table 10 Significant correlates from the semantic differential with the 12 MD

Concept	Patients' belief	r	p
'My treatment'	safe/dangerous	- 0.30	< 0.05
'Treatment - successful'	unlikely/likely	0.37	< 0.01
	improbable/probable	0.33	< 0.02
	true/false	- 0.31	< 0.05
'Treatment will cure me'	false/true	0.39	< 0.01
'My bronchitis'	causes financial worries/does not cause financial worries,	- 0.30	< 0.05
	bad/good	- 0.27	< 0.05
'Myself as I would like to be'	rugged/delicate	0.44	< 0.002
'The effect of my bronchitis on my family'	good/bad	0.32	< 0.05
'Physical exercise'	bad/good	0.29	< 0.05
	safe/dangerous	- 0.35	< 0.02
'My general health'	awful/nice	0.29	< 0.05

Table 11 Correlations between semantic differential scales and 12 minute walking distance

Scale	r
WHAT I THINK MY TREATMENT WILL BE LIKE:	
passive/active	0.06
strong/weak	- 0.20
safe/dangerous	- 0.30*
unpleasant/pleasant	- 0.12
worthless/valuable	0.26
long/short	0.09
laborious/effortless	- 0.22
boring/interesting	0.14
bad/good	0.22
fast/slow	- 0.07
old/new	0.24
nice/awful	- 0.05
THE TREATMENT I SHALL RECEIVE SHALL BE SUCCESSFUL:	
unlikely/likely	0.37***
possible/impossible	- 0.10
improbable/probable	0.33**
true/false	- 0.31*
THE TREATMENT I SHALL RECEIVE WILL COMPLETELY CURE ME:	
probable/improbable	- 0.16
impossible/possible	0.08
false/true	0.39***
likely/unlikely	- 0.20

MY BRONCHITIS:	r
sick/healthy	0.07
nice/awful	- 0.02
is never a nuisance/is always a nuisance	0.09
pleasurable/painful	0.05
does not make me feel bitter/makes me feel bitter	- 0.14
causes financial worries/ does not cause financial worries	- 0.30*
bad/good	- 0.27*
strong/weak	0.10
unpleasant/pleasant	- 0.16

MY BRONCHITIS CAN BE IMPROVED:	
impossible/possible	0.14
probable/improbable	0.04
false/true	0.175
likely/unlikely	0.02

MY BRONCHITIS IS A LONG TERM CONDITION:	
false/true	- 0.02
likely/unlikely	0.003
possible/impossible	0.16
improbable/probable	- 0.11

MYSELF:	r
healthy/sick	- 0.087
awful/nice	- 0.047
passive/active	0.21
pleasant/unpleasant	0.13
unsociable/sociable	- 0.17
hard/soft	0.01
bad/good	- 0.22
rugged/delicate	0.04
independent/dependent	- 0.17
slow/fast	0.143
unemotional/emotional	0.06
strong/weak	- 0.16

MYSELF AS I WOULD LIKE TO BE:	
soft/hard	- 0.16
rugged/delicate	0.44****
active/passive	0.003
bad/good	0.058
strong/weak	0.03
dependent/independent	0.004
unemotional/emotional	0.16
fast/slow	0.16

MY FAMILY:	r
hard/soft	0.04
bad/good	0.11
do not need me/need me	0.10
strong/weak	- 0.09
unpleasant/pleasant	- 0.09
nice/awful	0.07
understand my problems/ do not understand my problems	0.19
passive/active	- 0.17
independent/dependent	0.18
unemotional/emotional	0.18
helpful/unhelpful	- 0.08

THE EFFECT OF MY BRONCHITIS ON MY FAMILY:	
unpleasant/pleasant	- 0.12
strong/weak	- 0.02
unimportant/important	0.15
good/bad	0.32*
large/small	0.23
decreasing/increasing	0.005
kind/cruel	- 0.12
complex/simple	0.10
awful/nice	- 0.08

SMOKING:	r
wise/foolish	0.12
light/heavy	- 0.01
slow/fast	- 0.10
sociable/unsociable	- 0.09
bad/good	0.17
weak/strong	0.20
valuable/worthless	0.09
dangerous/safe	- 0.21
nice/awful	- 0.07
smoothing/aggrevating	- 0.16
pleasant/unpleasant	- 0.084

PHYSICAL EXERCISE:	
slow/fast	- 0.03
valuable/worthless	- 0.13
pleasant/unpleasant	- 0.084
weak/strong	- 0.01
safe/dangerous	- 0.35**
bad/good	0.29*
awful/nice	0.20
active/passive	- 0.063
important/unimportant	- 0.30
soft/hard	- 0.07

PHYSICAL EXERCISE IS GOOD FOR ME:	
probable/improbable	- 0.15
impossible/possible	0.04
unlikely/likely	0.13
true/false	- 0.24

MY GENERAL HEALTH:	r
awful/nice	0.29*
rugged/delicate	- 0.02
sick/healthy	0.20
pleasurable/painful	- 0.23
pleasant/unpleasant	- 0.23
bad/good	0.16
weak/strong	0.22

* = $p < 0.05$
** = $p < 0.02$
*** = $p < 0.01$
**** = $p < 0.002$

Table 12 Multiple regression analysis of factors correlating with the 12 MD

Variable	Multiple R	R2	% Variance
Perceived exertion	0.5188	0.2692	27
Treatment 'will cure me'	0.643	0.4134	14
Myself as I would like to be: 'delicate'	0.7398	0.5474	14
My bronchitis is: 'bad/good'	0.828	0.6856	13
My treatment will be: 'successful'	0.8529	0.7275	4
Forced vital capacity	0.8751	0.7658	4
My general health is: 'awful/nice'	0.8913	0.7944	3

Multiple R = 0.89

p = < 0.0001 accounting for approximately 79% of the variance

From the multiple regression analysis we can see that psychological factors, including perception of exertion, accounted for the greater part of the variance. Forced vital capacity was the only physiological factor accounting for only 4% of the variance. The full multiple regression equation may be written:

Predicted 12 MD (M) = 561 - 36 X 'RPE'
+ 52 X 'treatment will cure me'
- 8 X 'bronchitis is bad'
+ 67 X 'myself - delicate'
+ 49 X 'treatment will be successful'
+ .6 X FVC
+ 28 X 'smoking - awful'

6(3) SUMMARY OF RESULTS

1. Attitudes and beliefs of patients correlated significantly with the 12 MD.

2. Multiple regression analysis demonstrates that psychological factors are better predictors of exercise tolerance than physiological factors in this group of patients.

CHAPTER 7

DISPROPORTIONATE DISABILITY

7(1) AN INDEX OF DISPROPORTIONATE DISABILITY

From the results so far we have seen the great variability in the 12 minute distance walked by patients with chronic airflow obstruction, and the poor relationship to their measured ventilatory capacity. Clearly some patients walked greater distances in 12 minutes than others with similar vital capacities. We can express this degree of disproportionate disability or disproportionate 'ability' by comparing the walking distance and vital capacity on the same scale. One way to do this is to convert the variables into units of standard deviations. The 12 MD (metres) for subject x may be expressed as:

$$\frac{12\ MDx - \overline{12\ MD}\ (m)}{SD\ (m)}$$

or

$$\frac{12\ MDx - 795\ (m)}{291\ (m)}$$

Similarly FVC may be expressed as:

$$\frac{FVC - \overline{FVC}\ (L)}{SD\ (L)}$$

or

$$\frac{FVCx - 2.59\ (L)}{0.97\ (L)}$$

These parameters are known as 'Z' scores ie Z MD and Z FVC and have the following ranges, means and standard deviations:

	ZMD	ZFVC
n	50	50
range	-2.03 to 2.29	-1.64 to 2.69
mean	-0.002	0.0
SD	1.0	1.0

Figure 9 shows the 'Z' scores for the 12 MD and the FVC plotted in rank order according to the distance between the points, ie the degree of disproportion. From this we can see that those cases on the left of the figure are fairly well in proportion and that both the vital capacity and the 12 MD are in general similarly placed in their distribution. Patients with better than average VC's walk further than average and vice versa. On the right of the plot we see those cases where FVC and 12 MD are out of proportion. Those with greater than average FVC's walking less far than average, and vice versa. In other words the degree of disproportion may be seen as a continuum for any group of patients.

The range of disproportion may be expressed as an index:

$$\frac{ZMD}{ZFVC}$$

By adding a constant '10' to the numerator and denominator to eliminate negative values, the following range and mean ± SD is produced for a factor I have called DDZ (Disproportionate Disability)

'DDZ'

Range : 0.71 ± 1.34

Mean ± SD : 1.007 ± 0.118

Z MD + Z FVC BY RANK ORDER

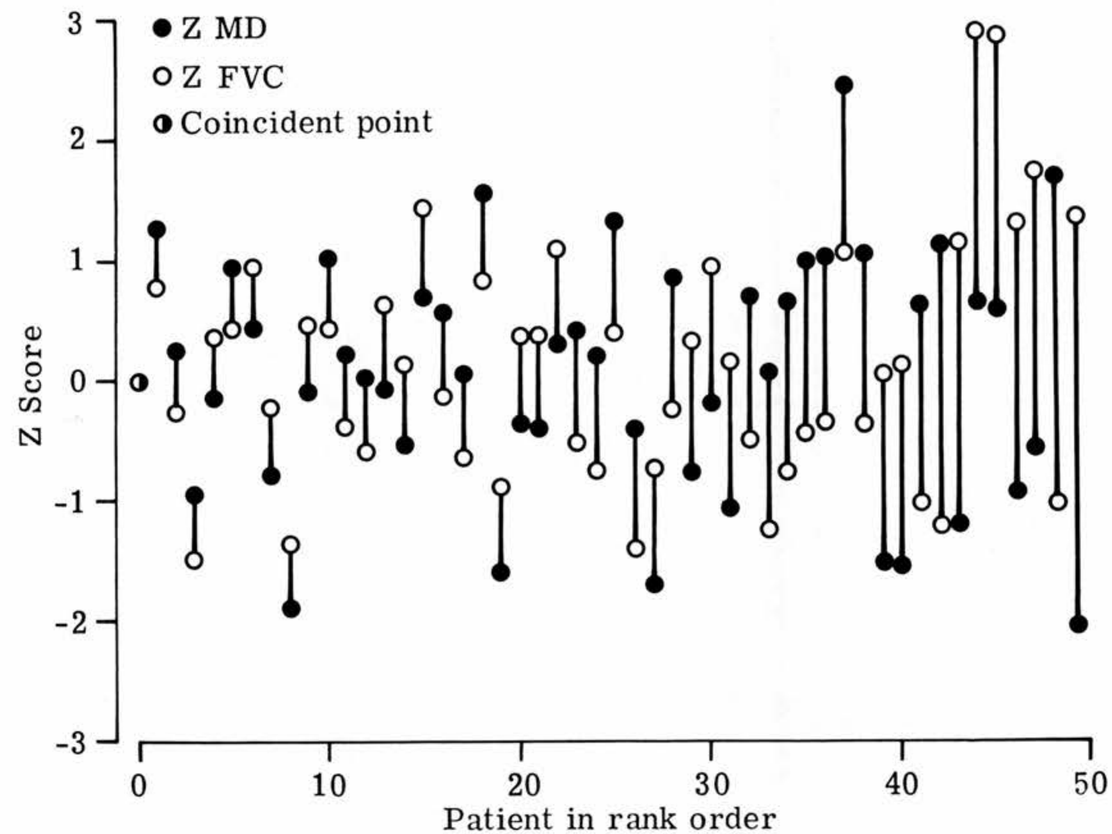
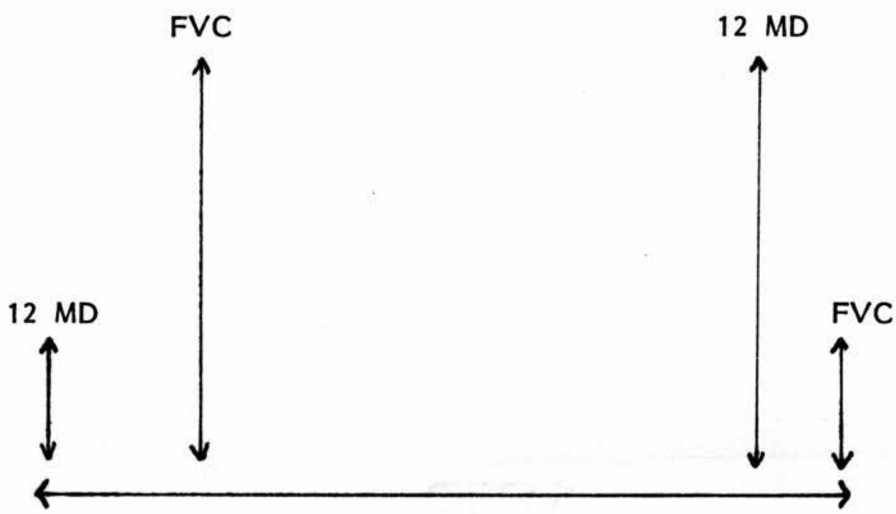


Figure 9

Figure 10 Examples of disproportionate 'disability' and 'ability' from the 'DDZ' score



DISPROPORTIONATE
DISABILITY (DDZ)

↑ DISABILITY

↑ ABILITY

<u>Patient 16</u>

FVC	3.7 L
12 MD	205 m
DDZ	0.72

<u>Patient 14</u>

FVC	1.0 L
12 MD	1150 m
DDZ	1.31

The factor describes a range of patients from those with disproportionately poor performance to those with disproportionately good performance (Figure 10).

7(2) CORRELATES OF DDZ

The degree of disproportion could clearly be related to age and sex, and the following analysis examines these possibilities.

Age Although age did not correlate significantly with the 12 MD ($r = -0.24$) it is possible that it could explain 'relative' performance measured by DDZ. However, analysis of variance for the 22 age groups and DDZ did not show a significant effect of age:

	Sum of squares	df	mean sq.
Between groups (age)	0.3712	21	0.177
Within groups	0.3150	28	0.113
Total0.6862			

$F = 1.57$ $p = 0.13$

Sex Sex may have a significant factor in that women might be expected to walk further for a given vital capacity. Analysis of variance did show a significant difference between the variances:

	Sum of squares	df	mean sq.
Between groups (sex)	0.0603	1	0.603
Within groups	0.6259	48	0.13
Total0.6862	49		

$F = 4.6273$ $p =< 0.04$

However the difference between the mean value for DDZ did not reach significance.

	n	mean	SD
Group 1 (men)	39	1.0	0.11
Group 2 (women)	11	1.07	0.12

$t = -2.01 \quad p = 0.06$

Thus any effect of sex on the index DDZ was very small.

DDZ, the index of disproportion was correlated with all the factors in the analysis. No significant relationship was found between the DDZ and age, arterial blood gases, the General Health Questionnaire, or scales of anxiety, depression or hostility. Table 13 lists the factors found to correlate significantly.

Again, the rating of perceived exertion was a significant inverse correlate so that those who were most disproportionately disabled felt exercise hardest. Attitudes that treatment was effortless and successful were correlated with a high DDZ score, ie those who had disproportionate 'ability'. In general negative beliefs and attitudes were correlated with disproportionate disability.

7(3) ARTERIAL BLOOD GASES AND DISPROPORTIONATE DISABILITY

Neither Pa02 or PaC02 correlated with DDZ, although this was not surprising from what we have seen before, that some of the most disabled hypoxic patients were divided into those who had a raised PAC02, and some who had a low PaC02. Scores for DDZ for the three groups divided according to their arterial PaC02 levels were as follows:

	n	DBZ ± SD
Group I increased PaC02	12	1.05 ± 0.09
Group II Normal PaC02	29	0.98 ± 0.1
Group III decreased PaC02	7	0.96 ± 0.15

These small differences were not significant and from this there is therefore no evidence that disproportionately poor performance was related to the type of blood gas disturbance seen in chronic bronchitis. However, the number of 'blue puffers' was small and it is possible that the trend seen of lower scores for DDZ amongst those with hypocapnia and hypoxia might have been more significant were they a larger group.

Similarly, patients divided by $Pa0_2$ did not differ significantly in their score of DDZ:

Group I	$Pa0_2 \geq 8$ kPa	0.98 ± 0.09
Group II	$Pa0_2 < 8$ kPa	1.02 ± 0.13

Table 13 Significant Correlates of an Index of Disproportionate Disability (DDZ)

Factor	r	p
RPE	- 0.29	< 0.05
my treatment:		
laborious/effortless	0.35	< 0.02
old/new	0.29	< 0.05
my treatment will be successful:		
improbable/probable	0.39	< 0.01
my treatment will cure me:		
probable/improbable	- 0.28	< 0.05
false/true	0.32	< 0.02
my bronchitis can be improved:		
impossible/possible	0.3	< 0.02
false/true	0.32	< 0.02
my family:		
do not need me/need me	0.32	< 0.02
independent/dependent	0.28	< 0.05

7(4) SUMMARY OF RESULTS

1. Using standarised scores of FVC and 12 MD a ratio of $\frac{\text{12 MD}}{\text{FVC}}$ reveals a continuous spectrum of disability/ability and was termed an index of 'disproportionate disability'.

2. This index correlated with PE and the attitudes and beliefs of patients. Thus positive attitudes towards treatment, illness (bronchitis) and about the family correlated positively with better than expected performance. Negative attitudes about treatment, bronchitis and family were associated with worse than expected performance.

3. Analysis of subgroups of blood gas abnormalities showed no difference in their scores of the disproportionate disability index.

CHAPTER 8

QUESTIONS TO DETECT 'DISPROPORTIONATE BREATHLESSNESS'

One of the chief findings of the examination of disproportionately breathless bronchitic patients by Burns and Howell was the occurrence of specific features of their breathlessness compared with appropriately disabled bronchitics. In order to examine whether or not these features of breathlessness are present amongst disabled bronchitic patients not selected on grounds of psychiatric disturbance, I constructed a short questionnaire - the Disproportionately Breathless Questionnaire (DBQ) consisting of the ten most significant items found in Burns and Howell's study. See Table (14).

First of all the total score out of ten was counted and called the 'DBQ'. This was not found to be of any value as a factor and did not correlate with perceived exertion ($r = 0.08$), the 12 MD ($r = -0.2$) or vital capacity ($r = 0.08$).

The main interest of the factor however, was whether or not the presence of these symptoms were related to disproportionate disability i.e. in this study the DDZ factor. This was not the case and a correlation matrix was then computed for the individual questions to see whether any of the individual components of the total score were of significance (Table 14).

The strongest association was Q1, with the answer that 'breathlessness does not always relate to exertion', negatively correlating with relatively good performance, i.e. the more patients felt their breathlessness did not relate to exertion, the less distance they walked than expected. Adding the strongest correlates together to form a short three question factor, (Q1 + 5 + 9) produced a strong negative correlate of DDZ, which may help to identify patients with disproportionately poor exercise tolerance:

1. Breathlessness is not related to exertion.

2. Breathlessness improves after alcohol or sedatives.

3. Breathlessness not helped by expectorating sputum.

Table 14 Disproportionate Breathlessness Questionnaire (DBQ)

Please answer the following questionnaire by responding Yes or No to the following statements about your breathlessness.

Your breathlessness:

1.	does not always relate to exertion	Y/N
2.	occurs for very short periods at a time	Y/N
3.	is worse if you are anxious	Y/N
4.	is not improved by stopping smoking	Y/N
5.	improves after alcohol or sedatives	Y/N
6.	occurs during conversation	Y/N
7.	causes a fear of sudden death	Y/N
8.	causes difficultly in getting air in not out of the lungs	Y/N
9.	does not help by bringing up sputum	Y/N
10.	<u>is not</u> relieved by rest	Y/N

Table 15 Correlation between questions from disproportionate breathlessness questionnaire 'DBQ' and disproportionate disability 'DDZ'

Questions:	r
1	- 0.325 *
2	- 0.073
3	0.169
4	- 0.043
5	- 0.231
6	- 0.017
7	0.002
8	0.023
9	- 0.28 *
10	- 0.102
(1-10)	- 0.215
1 + 5 + 9	- 0.445 **

* $p = < 0.05$
** $p = < 0.002$

SUMMARY OF RESULTS

1. The total score on a questionnaire of 10 key features thought to relate to disproportionate breathlessness (DBQ) did not correlate with the index disproportionate disability (DDZ).

2. Certain questions correlated with DDZ allowing a factor of three key symptoms to be derived which correlated more closely with DDZ.

CHAPTER 9

STUDY II. PSYCHOLOGICAL AND PHYSIOLOGICAL FACTORS AFFECTING 2, 6, 12 MINUTE WALKING TESTS

9(1) INTRODUCTION

This study was carried out to examine whether walking tests of shorter duration might bear the same relationship to measurement of impairment, perception of breathlessness and psychological factors. The protocol follows the same patterns as before:

1. Measure of impairment
   (FEV_1, FVC, D_LCO, KCO, $Pa0_2$, $Pa0_2$)

2. 2 6 and 12 Minute Walking Test (randomised)

   Assessment of effort and breathlessness following exercise

3. Examination of mood, and attitudes and beliefs

Thus the study allows comparison of D_LCO and FVC as correlates of walking distances, as well as comparison of scales of effort and breathlessness.

9(2) PATIENTS

Patients with chronic bronchitis according to MRC criteria (4). They were either outpatients attending clinics in respiratory diseases or were inpatients having recovered from an acute exacerbation of chronic bronchitis. They were excluded if suffering from peripheral vascular disease, engine or locomotor disorder and were 75 years of age or over.

9(3) PHYSIOLOGICAL MEASUREMENTS

1. Ventilatory capacity by spirometry as already described (130).

2. Measurement of single breath transfer factor for carbon monoxide and derivation of KCO (146).

3. Arterial blood gases.

9(4) EXERCISE TESTS

In order to familiarise themselves with the demands of the walking tests, patients all started their exercise tests with a practice 12 minute walk. Following at least 20 minutes rest, they were then assigned to a 2, 6 or 12 minute walk in a randomised order, again with at least 20 minutes rest between exercise tests. Walks were completed on the same day within 2 days of the baseline pulmonary function test. No encouragement was given during the walking tests.

9(5) SCALES OF BREATHLESSNESS

Following each walk, patients were asked to complete estimations of their breathless and effort using three scales:-

a) Perceived exertion (See Appendix 139)
b) Perceived breathlessness (see below)
c) Visual Analgoue Scale (see below)

Perceived Breathlessness

Using the principles of the 'perceived exertion' scale developed by Borg (88). Burdon et al used a modified scale to assess breathlessness rather than exertion and founded a useful scale to assess breathless during induced bronchoconstriction (149).

Rating of Perceived Breathlessness (RPB)

0	not breathless at all
0.5	just noticeably breathless
1	very slightly breathless
2	slightly breathless
3	moderately breathless
4	somewhat severely breathless
5	severely breathless
6	------------
7	very severely breathless
8	------------
9	very, very severely breathless
10	Maximal

Visual Analogue Scale (VAS) (Ref 89)

A 100 mm VAS was drawn with two qualifications at either end of a horizontal line:

not breathless at all	______________________________	the most breathless I have ever been

Patients were asked to draw a cross on a point on the line which most closely approximated their sensation of breathlessness following exercise.

9(6) PSYCHOLOGICAL QUESTIONNAIRE

From the larger study a modified and shortened examination of psychological factors was conceived.

Disturbance of mood was measured again by the Multiple Affect Adjective Check List (MAACL) and a shortened 'semantic differential' was constructed using the following concepts and headings from which significant factors emerged in the earlier study. These were followed by the same sets of scales and can be referred to in the Appendix.

Concepts and Headings for Shortened Semantic Differential

'My medical treatment will be successful'
'Myself'
'The effect of my bronchitis on my family'
'My medical treatment will be'
'My general health'
'My bronchitis'
'Physical exercise'
'Physical exercise is good for me'
'My bronchitis can be improved'
'My treatment can cure me'

Table 16 Age, Ventilatory Capacity, D_LCO, KCO, PaO_2 and $PaCO_2$ of 22 patients with chronic bronchitis (Study II).

	Range	Mean	± SD
Age (yrs)	52-73	63.2	5.5
FEV_1 (L)	0.3-2.5	1.5	0.96
FVC (L)	1.5-4.6	3.2	0.9
D_LCO mmol/min kPa	2.27-10.25	5.84	2.52
KCO mmol/min kPa L	0.58-1.43	1.03	0.3
PaO_2 (kPa)	4.5-12.9	9.07	1.89
$PaCO_2$ (kPa)	3.9-9.1	5.3	1.3

9(7) ANALYSIS

Correlation (product moment) by simple computer programme. Differences between means by Wilocxon Rank.

9(8) RESULTS

Patients 22 male patients took part in the study, with the following details of age, ventilatory capacity, transfer factor for carbon monoxide, arterial blood gases (Table 15; Figure 11).

See Appendix (page 173) for individual results.

9(9) WALKING DISTANCES, SPEEDS AND CORRELATIONS WITH PHYSIOLOGICAL VARIABLES

The walking distances were as follows:- (See Figure 12)

Test	Range (m)	Mean (m)	± SD (m)
2 MD	87 - 233	165.7	36.4
6 MD	180 - 655	437.5	113.9
12 MD	406 - 1285	855.3	257.8

Velocity during m/min	Range (m/min)	Mean (m/min)	± SD (m/min)
2 MD	43.5 - 116.5	84	18.2
6 MD	30 - 109	72.7	22.3
12 MD	33 - 107	71.4	21.5

* $p = < 0.01$ (Wilcoxon Rank)

Thus patients walked more quickly during the 2 MD than the 6 MD or 12 MD, which were completed at the same pace.

$FEV_{1.0}$ AND FVC OF PATIENTS

Study II

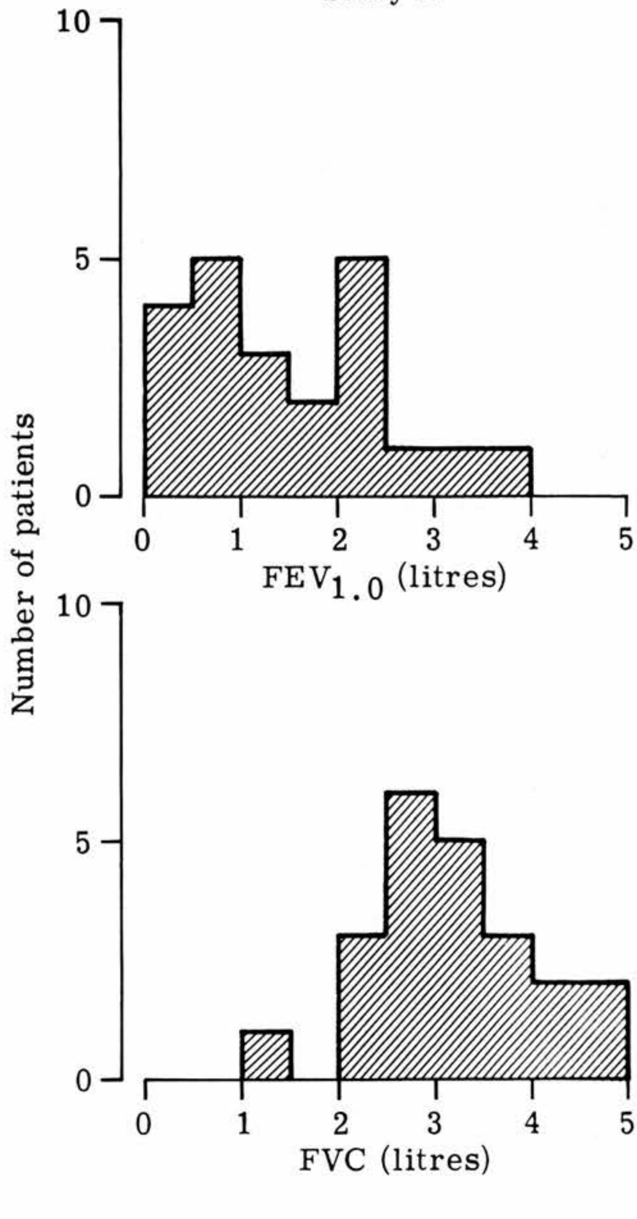


Figure 11

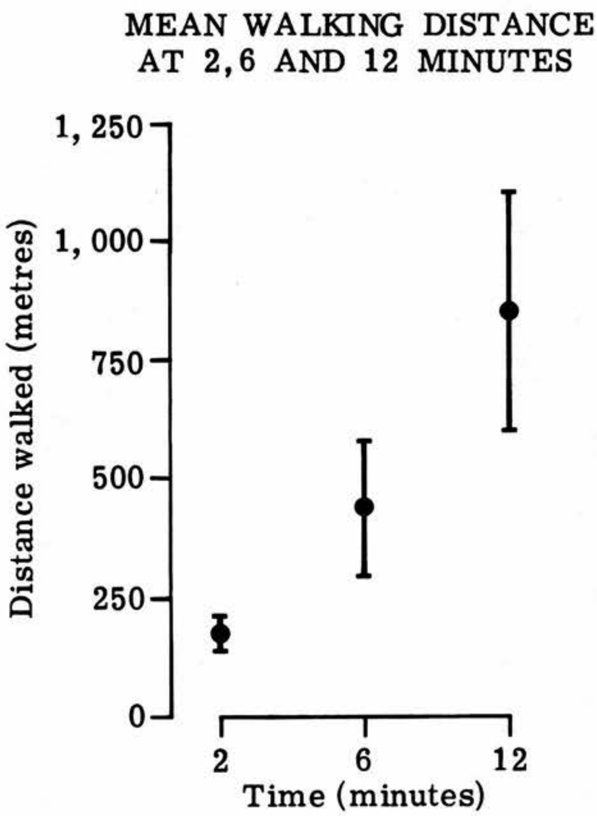

MEAN WALKING DISTANCE
AT 2,6 AND 12 MINUTES
Distance walked (metres)
1,250
1,000
750
500
250
0
2
6
12
Time (minutes)

Figure 12

The three tests were all intercorrelated although the 6 MD and 12 MD were much more closely related than the 2 MD with the 6 or 12 MD:

2 MD v 6 MD, r = 0.62: 2 MD v 12 MD, r = 0.76:
6 MD v 12 MD, r = 0.98

9(10) CORRELATIONS WITH PHYSIOLOGICAL VARIABLES

All the walking tests correlated with physiological variables, with the exception of $Pa0_2$

	2 MD	6 MD	12 MD
FEV_1	0.75+++	0.81+++	0.8+++
FVC	0.78+++	0.82+++	0.81+++
D_LCO	0.57++	0.61++	0.65++
KCO	0.49+	0.57++	0.63++
PaO_2	0.25	0.32	0.39
$PaCO_2$	- 0.45+	- 0.52+	- 0.52+

+	p = < 0.05
++	p = < 0.01
+++	p = < 0.001

Thus the correlations between ventilatory capacity and walking distances were generally high. D_LCO and KCo were significantly correlated with walking distances, although with a lower order of significances that that found for ventilatory capacity. The level of carbon dioxide tension $PaCO_2$ correlated negatively with walking distance. The 2 MD was slightly less well correlated with all these variables compared with the 6 or 12 MD.

9(11) PERCEIVED EXERTION, PERCEIVED BREATHLESSNESS AND VAS

The following table shows the correlations between the walking tests and the scales of perceived exertion, perceived breathlessness and the VAS.

	'PE'	'PB'	VAS
2 MD	- 0.49+	- 0.43	- 0.27
6 MD	- 0.69++	- 0.72+++	- 0.5+
12 MD	- 0.64++	- 0.64++	- 0.66++

+ p =<0.05
++ p =<0.01
+++ p =<0.001

In similar fashion to the first study there were significant negative correlations between the intensity of perception of effort and breathlessness and walking distances.

The closeness of the correlations for PE and PB suggest that effort and breathlessness are perceived as similar feelings at the end of exercise in bronchitic patients. They were highly intercorrelated for each walk; $r = 0.92$ (12 MD); $r = 0.87$ (6 MD); and $r = 0.86$ (2 MD). In addition the mean scores for each walk were remarkably similar suggesting that the degree of limiting effort or dypsnoea is similar for patients whether they walk for 2, 6 or 12 minutes:

Mean scores for PE and PB for each walking test

	2 MD	6 MD	12 MD
PE	11.6 ± 3.1	12.8 ± 3.2	12.6 ± 2.8
PB	2.6 ± 1.8	3.3 ± 2.1	3.3 ± 1.7

The visual analogue scale of breathlessness did not appear to correlate as closely with the exercise tests and generally patients found it more difficult to understand the use. However, the method of use of the VAS may not have been as accurate as others and I discuss this later.

9(12) PSYCHOLOGICAL CORRELATES OF WALKING TESTS

In this study, mood scales from the Multiple Affect Adjective Check List did not correlate with exercise tests:

Correlation of anxiety, depression and hostility scales with 2, 6 or 12 MD:

	2 MD	6 MD	12 MD
Anxiety	0.12	0.02	0.03
Depression	- 0.36	- 0.36	- 0.29
Hostility	0.01	0.01	0.02

9(13) SEMANTIC DIFFERENTIAL (ATTITUDES AND BELIEFS OF PATIENTS)

10 of the 42 scales (from 8 to 10 concepts or headings) showed significant correlation with the walking tests often with all three tests. (Table 17).

Again, showing similar results to the first study, positive attitudes towards medical treatment, general health and the severity of illness ("my bronchitis") correlated with exercise performance i.e. the more positive the attitude or beliefs, the greater the walking distance. This was true for all the walking tests.

Negative attitudes about "myself" the illness "bronchitis" and feeling physical exercise to be "worthwhile" or "unpleasant" all demonstrated significant negative correlations with walking distance i.e. the more negative the attitude and beliefs held, the worse the exercise tolerance.

9(14) SUMMARY OF RESULTS

1. Patients walk faster when asked to do so for 2 minutes than 6 or 12 minutes.

2. They reach similar levels of exertion and breathlessness after all walking times, and scales of exertion and breathlessness correlated significantly and inversely with distance walked.

3. Perception of exertion and breathlessness are closely related, and correlate significantly and inversely with walking distance.

4. Attitudes and beliefs of patients correlate with a self paced timed walking test, whether for 2, 6 or 12 minutes.

Table 17 Significant correlations between attitudes and beliefs from the semantic differential and 2, 6 and 12 minute walking test

Factor	r (2 MD)	r (6 MD)	r (12 MD)
My treatment will be successful: improbable/probable	0.75++++	0.55+++	0.56+++
Myself: healthy/sick	- 0.54+++	- 0.43+	- 0.42+
The effect of my bronchitis on my family: unimportant/important	(-0.28)	-0.5++	-0.57+++
My treatment will be: unpleasant/pleasant	0.43+	(0.38)	(0.35)
My general health: awful/nice	0.58+++	(0.41)	(0.39)
My bronchitis is: never a nuisance/ always a nuisance	(-0.22)	(-0.41)	-0.47+
My bronchitis is: bad/good	(0.11)	(0.35)	0.42+
Physical exercise is: valuable/worthless	-0.52++	-0.54+++	-0.53++
Physical exercise is: pleasant/unpleasant	(-0.41)	-0.45+	-0.46+

My treatment will cure me: probable/<u>improbable</u>	-0.66++++	-0.46+	-0.49+

+ = $p < 0.05$
++ = $p < 0.02$
+++ = $p < 0.01$
++++ = $p < 0.001$

Figures in ( ) = not significant

CHAPTER 10

DISCUSSION

The findings of these studies may have implications for future studies of disability in chronic bronchitis and other chronic diseases. However, before discussing these more general conclusions, I wish first to assess the significance of the results in the light of current literature. As the second study essentially compliments the first the discussion will refer to both under common headings.

10(1) HOW TYPICAL WERE THE PATIENTS STUDIED?

Examination of the mean ventilatory capacities of the two groups shows that they are not strictly comparable. The first and larger group from which most of the data has been obtained were recruited over a two year period throughout the years. The smaller group were recruited exclusively in the summer over a short two month period, mainly from outpatients. This may explain why they were less disabled in terms of their ventilatory capacities and walking distances. However, both groups appear to walk appropriately far (comparing means) for their vital capacities when compared with some previous groups studies (Figure 13). The age and sex distributions of the larger group were similar to most studies. The figure also shows just how different mean walking distances are for different group studied, even when they appear to have similar mean vital capacities. Few studies give details of where and how the walking tests were carried out and the variation seems to support Guyatt's view that more details of standardisation should be given in studies using these types of walking tests (58).

From a psychiatric aspect there is no possibility that the patients were overtly disturbed or they would have been excluded from the study. However, the General Health Questionnaire (GHQ) suggest there was a high prevalence of psychiatric morbidity. Taking a score of > 4 as an indicator of the probability that the subject may

MEAN 12 MD AND MEAN FVC
FROM STUDIES OF EXERCISE TOLERANCE IN CHRONIC BRONCHITIS

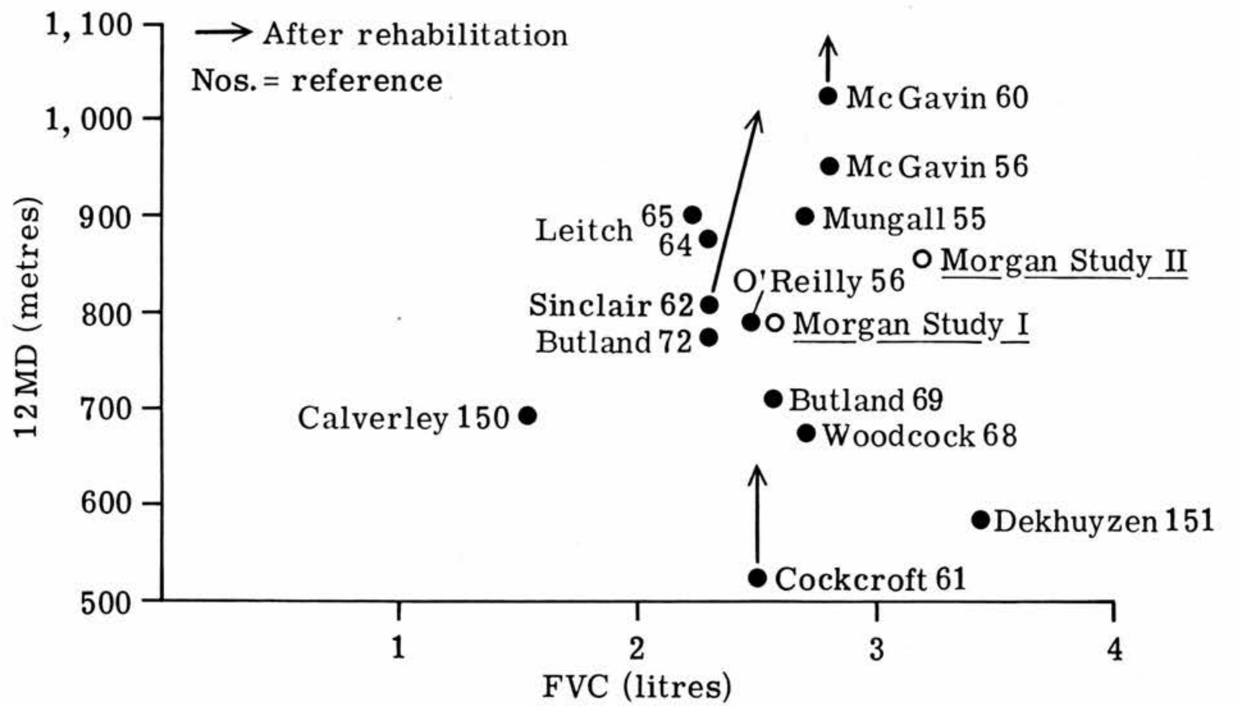


Figure 13

be a psychiatric case, 42/50 (86%) of patients passed this threshold. This compares with previous studies of bronchitic patients using the same criteria. Rutter found 11/23 (48%) of bronchitic patients scored > 4 compared with 3/23 (13%) age matched controls (124). Rosser et al found 39/65 (60%) to score higher than 4 (122). Raising the threshold for "casesness" to > 6 and > 10 would still have indicated a prevalence of psychiatric morbidity of 37/50 (74%) and 29/50 (58%) respectively. In general medicine settings, the average prevalence of psychiatric morbidity is 30% and the threshold recommended by Goldberg was adjusted to this level (134). The findings are therefore broadly in agreement with other studies that psychiatric morbidity is common amongst bronchitic patients. Faulkner's work also supports this, finding a 37% prevalance of psychiatric disturbance amongst bronchitics, using a psychiatric interview (123).

Although the patients displayed this level of psychiatric morbidity, the only patients with a low $PaCO_2$ were also hypoxic, and so whilst the hypoxia alone could not wholly account for the hyperventilation, these hypocapnic patients could not be termed 'psychogenic' hyperventilators. The main group of patients studied were therefore typical of many attending outpatients with severe chronic airflow obstruction, displaying a high degree of psychiatric morbidity, but performing an exercise test as a group appropriately for their degree of impairment.

10(2) RELATION BETWEEN PHYSIOLOGICAL FACTOR AND WALKING DISTANCE

The low level of significant correlation between vital capacity and walking distance is similar to most other studies. Generally FVC and D_LCO appear to be the best predictors of walking distance. In the second study FVC was more closely correlated with 2, 6 and 12 minute walking distance than D_LCO, similar to the findings of a recent Dutch study (151). Mungall and Hainsworth and O'Reilly found D_LCO to be the only physiological variable to correlate with the 12 MD. From these other studies the correlations between FVC and 12 MD have been variable: McGavin (54) $r = 0.4$, $p = < 0.05$, n = 22: Leitch (64) r = 0.67, p = < 0.001, n = 24: Leitch (65) r = 0.6, p = < 0.001, n = 24; Mungall and Hainsworth (55) 'r' not stated, p > 0.05, n = 13: O'Reilly (56) 'r' not stated, p = > 0.05, n = 10. The variation in the value of 'r' may be partly explained by the different numbers studied. If for example the relationship between the FVC and 12 MD is usually weakly significant at the 5% level, r would have to be > 0.4 for 22 subjects, and > 0.28 for 50 subjects. The studies where FVC has not correlated with 12 MD have been of very small numbers, where the effect of other variable may have been greater.

In study I, groups divided by their PAO_2 or $PaCO_2$ were not different in their 12 MD or perceived exertion. The overall lack of correlation between PaO_2 and $PaCO_2$ and other variables suggest that whilst the type of blood gas derangement may have important clinical consequences, it does not have much influence on overall disability. In the second study there was a weak inverse correlation between $PaCO_2$ and the 2, 6 and 12 minute walk. However, the patients with a raised $PaCO_2$ had the worse ventilatory capacities, so the $PaCO_2$ was not an independent factor. The data therefore agrees with that of Johnson et al who exercised two groups of patients divided by $PaCO_2$ level, but better matched for ventilatory capacity (49). No difference between exercise tolerance or breathlessness could be detected. It seems difficult to reconcile these findings with the long held opinion that 'pink puffers' are more breathless than 'blue bloaters'. However, no other exercise studies have been done where groups have been well matched for the degree of ventilatory impairment. It may well be that the differences between the groups lie in their patterns of adaptation to exercise, but are not actually limiting factors during self-paced exercise tests. Clearly this is still an area for further study, and a laboratory approach to self-paced exercise outlined by Guz and colleagues seems to be the correct one (152).

10(3) PERCEIVED EXERTION, PERCEIVED BREATHLESSNESS AND THE VISUAL ANALOGUE (VAS)

The close inverse correlation between perceived exertion and the 12 MD, and its lack of correlation with the degree of ventilatory impairment confirms that subjective awareness of effort is a strong independent factor, which outweighs physiological factors in the prediction of exercise tolerance. In the second study, I compare the use of scales of perceived exertion, perceived breathlessness, and a VAS of breathlessness. Generally I found patients more easily understood Borg's scales, although many studies comment on the simplicity of use of VA scales.

The VAS had at the extreme end the statement - "the most breathless I have ever been". Studies evaluating VA scales of dyspnoea usually 'fix' this point with a prior exercise test to exhaustion so patients can have direct experience of this degree of dyspnoea. I did not do this, and it may be why in the comparative study the VAS correlated less closely with the walking test that the Borg scales. The high correlation between RPE and RPB suggest that patients could not distinguish between perception of 'effort' and 'breathlessness'. Following the 2, 6 and 12 MD the average RPE and RPB responses were the same. Similar findings that both normal subjects and patients carry out different submaximal exercises to the same degree of physiological strain have been described previously (50). They suggest that walking pace is in some way 'pre-set' by patients according to the duration of exercise and a certain degree of effort and breathlessness. It is not surprising that this degree is influenced by psychological factors.

10(4) WHICH WALKING TEST IS BEST?

If this is true, and patients stress themselves to the same degree by much shorter tests, then the duration clearly need not be twelve minutes. Originally there were sound physiological reasons for the choice of twelve minutes being an optimum time for submaximal exercise (53). However, studies of shorter walking times have shown that patients tend to walk at a steady pace after an initial burst of speed. Butland found a high correlation between the 2, 6 and 12 minute walks but noted that the variance for the 6 and 12 minute walk was greater than for the 2 minute walk. In my second study, not only did patients walk significantly faster during the 2 MD, but the correlation between the 6 and 12 MD was much closer than that between the 2 MD and the longer walks. The variance of the 6 and 12 MD was also found to be greater than the variance of the 2 MD. In addition, all the scales of subjective exertion and breathlessness correlated more closely with the 6 and 12 MD than with the 2 MD. On the basis of convenience, closer correlations with exercise of longer duration, and with subjective exertion and breathlessness, the 6 MD seems the optimum timed walk.

In the second study of a slightly fitter population, all walks correlated well with FVC and D_LCO. It is possible that the 2 MD may be as useful as longer tests in detecting acute change e.g. the effect of bronchodilator drugs, but the longer walks retain their usefulness in studies of overall disability, where endurance is also an important factor.

10(5) EFFECT OF PSYCHOLOGICAL FACTORS ON WALKING DISTANCE

Perception of breathlessness and effort are clearly the strongest psychological factors to emerge as correlates of walking tests. However, many other psychological factors correlated with the 12 MD and emerged in the multiple regression analysis as more important predictors than vital capacity. The mood scales from the 'check list' MAACL correlated negatively with 12 MD i.e. the more depressed, anxious or hostile, the less the distance walked. These scales were highly intercorrelated, and as such make one suspect that they are not measuring distinct moods at all. It is possible that many of these disabled patients are depressed, anxious and hostile at the same time; such a combination of emotions is understandable. However, in a study of a stressor on EMG responses in 10 muscle sites in normal subjects, MAACL was used to assess the affective changes related to the application of the stressor (154). A correlation of $r = 0.36$ ($p = < 0.02$) was found between anxiety and lumber muscle tensions. However, much higher correlations were found between the scales of anxiety, depression and hostility from $r = 0.66$ to $r = 0.74$. When the scores were added, a significant correlation between a scale termed 'total negative affect' and a scale of neuroticism was obtained. This is similar to my own findings, when the mood scales were added together, the 'total negative affect' correlated with the psychiatric disturbance. Objection to this is principally that the ranges of scores for each 'mood' from MAACL are different and are probably not simply additive. Without the secondary support of a psychiatric interviewer, the sensitivity of mood scales like MAACL to distinguish between different moods must remain in doubt. Other studies have noted similar associations between anxiety, depression and walking distances in bronchitics (155, 156).

Studying the attitudes and beliefs of patients marks a departure from the usual approach to detecting psychological factors in chronic disease, which is to try and identify actual psychiatric disturbance. However, Burns and Howell in their study in 1969 noted that some attitudes and beliefs of their 'disproportionately breathless' patients differed from the controls. Patients attributed pessimism about their illness and treatment to information allegedly given to them by Doctors e.g. 'your chest is very bad and always will be'. 'I can do nothing for you'. Rutter used the semantic differential in her study of prognostic factors in chronic bronchitis. Certain attitudes and beliefs predicted time lost from work better than physiological measures of illness severity, and were more powerful predictors of outcome than other psychological variables.

In any study requiring multiple comparisons or correlations between variables there is the possibility that 'significant' association may arise by chance. Considering this possibility, one can calculate the number of results that could be expected to have arisen by change as k x p, where k is the number of variables and p the level of significance chosen (157). The possibility exists therefore, that of the 109 factors used in the analysis of the semantic differential 109 x 0.05 (5-6) may give rise to a significant correlation at the 5% level by chance, and 109 x 0.01 (1) may arise at the 1% level. In the event, twelve significant correlates were obtained. They all made intuitive sense and it seems very unlikely that they arose by chance. Positive attitudes correlated with good performance, negative attitudes with poor performance. These factors together were more powerful predictors of the 12 MD than vital capacity. The second smaller study using fewer factors yielded similar results, even when physiological factors were more closely correlated with walking distances. Since these studies have been completed a further study of psychological factors affecting the 6 MD using the same semantic differential has been repeated in Newcastle, again yielding similar results (155).

That attitudes and beliefs of patients affect even these short walking tests supports the idea that patients approach exercise with a pre-determined limit on pace. As we have seen, apart from an initial burst patients tend to walk thereafter at remarkably similar speeds. The intensity with which they perceive effort and breathlessness must influence this, and must itself be influenced by psychological factors and past experience. Attitudes and beliefs about exercise and breathlessness must be important in "setting" this intensity.

10(6) DISPROPORTIONATE DISABILITY

The concept of disproportionate disability was developed by Burns and Howell to describe patients with completely inappropriate responses to their mild airflow obstruction. Their patients were much more disturbed psychiatrically than the control group and probably had two diagnoses, chronic airflow obstruction and a psychiatric or personality disorder. The patients studied in this thesis were not the same. They appeared to be fairly average chronically disabled patients. However, within the group a wide spectrum of exercise performance was seen and I chose to call those performing relatively poorly for their degree of impairment, 'disproportionately disabled'. The group could be seen as a spectrum from relatively bad to relatively good performance. The many significant correlates of an index to describe this spectrum were psychological factors, including perceived exertion. Again positive attitudes were associated with relatively good performance and vice versa. Rosser and Guz have questioned this concept of disproportionate breathlessness on the basis that in their own study of chronic bronchitis, features of breathlessness thought to be characteristic of disproportion were found in all the severely breathless patients whether there were severe lung disease present or not (158).

Using a similar range of questions (DBQ), the overall score did not correlate significantly with the index of disproportionate disability, although certain key questions did. The correlations were not high however, and clearly merely enquiring about the nature of a patient's breathlessness is not sufficiently sensitive to detect disproportionate dyspnoea. A self-paced exercise test is an essential ingredient of the whole evaluation. Disproportionate disability (which implies measurement of exercise tolerance) is an easier concept to measure and understand than disproportionate dyspnoea, and can be identified across a wide spectrum of ventilatory impairment.

Clearly within any group of disabled bronchitic patients entering a rehabilitation programme, there must be a similar spectrum of relatively good, and relatively poor performance. Improvement in exercise tolerance is variable following such programmes (see Figure 13) and it seems likely that the composition of the group in terms of their relative, or disproportionate disability is important. Patients who demonstrate good performance for their degree of impairment may not be able to improve further. The results of rehabilitation may either be that the breadth of the spectrum of disproportionate disability decreases as all patients become more 'appropriately' disabled, or that the spectrum remains unchanged as all patients improve equally. I feel it is more likely that rehabilitation would offer more to those shown to be disporportionately disabled, and that this approach may improve the selection of patients most likely to benefit from rehabilitation.

10(7) REHABILITATION AND PSYCHOLOGICAL FACTORS

If psychological factors are important predictors of disability, then treatments aimed at modifying adverse psychological reactions should decrease disability. Whilst a number of controlled studies have shown the benefit of a programme of exercise training, few have considered psychological changes during rehabilitation (60, 62). In a rehabilitation study of a 6 week programme of a wide variety of exercises, a significant improvement in 12 MD was seen over a control group who also demonstrated a large placebo effect (61). However, psychological changes were seen in both groups and no correlation could be found between psychological and physiological improvement (159).

Similar psychological findings were obtained from a controlled study of prednisolone therapy in chronic bronchitis, where psychological improvements could not be related to changes in walking distance (160). A purely psychotherapeutic study compared the effect of different degrees of psychoterapy on breathlessness and exercise tolerance in bronchitic patients (122). Patients were divided into an analytic group, a supportive group, a nurse only group and a control group. No changes in exercise tolerance were seen in any of the treatment groups. The only group to show an improvement in a dyspnoea grade received psychological support from a nurse who had no psychoterapeutic training. However, this group also increased their depression rating.

Overall the results of such an expensive time and manpower consuming study were not encouraging in terms of practical outcome. The fact that only the nurse group achieved a reduction in breathlessness (albeit without an increase in walking distance) suggests that a simple approach might be effective in modifying some of the attitudes and beliefs found here to be significant accompaniments of severe disability, whether cause or effect.

Reducing fear of breathlessness and exercise, and discouraging pessimism about illness and treatment may help some patients to break out of a cycle of depression, breathlessness and disability. Equally we should be careful as Doctors that we do not lay down the foundations of negative attitudes and beliefs. Mention of 'irreversible' obstruction and 'respiratory failure' should be confined to the case notes and kept clear of the consulting room.

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APPENDIX

APPENDIX SECTION I

PATIENT'S QUESTIONNAIRES

1. Instructions for the 12. M.D.

2. Borg's Scale of Perceived Exertion.

3. M.R.C. Grade.

4. General Health Questionnaire.

5. Multiple Affect Check List.

6. Semantic Differential.

1. Instructions for the 12 M.D.

"I would like you to walk as far as you can along the corridor in 12 minutes, to keep going continuously if possible, but do not be concerned if you have to stop and rest. You should aim to feel at the end of 12 minutes that you could not have covered more ground in the time". No further encouragement is given throughout the test.

2. Borg's Scale of "Perceived Exertion"

"Select the number that corresponds with the expression that best describes how hard you found the walking test".

6	
7	very very light
8	
9	very light
10	
11	light
12	
13	somewhat hard
14	
15	hard
16	

17	very hard
18	
19	very very hard

3. M.R.C. Dyspnoea Grade

	Grade
Are you breathless at test or on minimal effort e.g. dressing?	5
Are you breathless after walking 100 yards on the level?	4
Are you able to walk for 1 mile at your own pace, but unable to keep up with people of your own age?	3
Can you keep up with people of you own age but not on hills or stairs?	2
Otherwise?	1

General Health Questionnaire

Please read this carefully. We should like to know if you have had any medical complaints, and how your health has been in general over the past few weeks. Please answer all the questions on the following pages simply by underlining the answer that you think most nearly applies to you. Remember that we want to know about present and recent complaints.

It is important that you try to answer ALL the questions.

Have you recently:

1. Been able to concentrate on whatever you are doing	Better than usual	Same as usual	Less than usual	Much less than usual
2. Lost much sleep over worry	Not at all	No more than usual	Rather more than usual	Much more than usual
3. Been having restless, disturbed nights	Not at all	No more than usual	Rather more than usual	Much more than usual
4. Been managing to keep yourself busy and occupied	More so than usual	Same as usual	Less than usual	Much less than usual

5. Been getting out of the house as much as usual	More so than usual	Same as usual	Less than usual	Much less than usual
6. Been managing as well as most people in your shoes	More so than usual	Same as usual	Rather less than usual	Much less than usual
7. Been feeling on the whole you were doing things well	Better than usual	About the same	Less well than usual	Much less well
8. Been satisfied with the way you have carried out your tasks	Better than usual	About the usual	Less well than usual	Much less well
9. Been able to feel warmth and affection for others	Better than usual	About the same as usual	Less well than usual	Much less well
10. Spent much time chatting with people	Not at all	No more than usual	Rather more than usual	Much more than usual
11. Felt you are playing a useful part in things	More so than usual	Same as usual	Less useful than usual	Much less useful
12. Felt capable of making decisions about things	More so than usual	Same as usual	Less useful than usual	Much less useful

13. Felt constantly under strain	Not at all	No more than usual	Rather more than usual	Much more than usual
14. Felt that you could not overcome your difficulties	Not at all	No more than usual	Rather more than usual	Much more than usual
15. Been finding life a struggle all the time	Not at all	No more than usual	Rather more than usual	Much more than usual
16. Been able to enjoy your normal day to day activities	More so than usual	Same as usual	Less than usual	Much less than usual
17. Been taking things hard	Not at all	No more than usual	Rather more than usual	Much more than usual
18. Been getting scared or panicky for no good reason	Not at all	No more than usual	Rather more than usual	Much more than usual
19. Been able to face up to your problems	More so than usual	Same as usual	Less able than usual	Much less able
20. Found everything getting on top of you	Not at all	No more than usual	Rather more than usual	Much more than usual

21. Been feeling unhappy or depressed	Not at all	No more than usual	Rather more than usual	Much more than usual
22. Been losing confidence in yourself	Not at all	No more than usual	Rather more than usual	Much more than usual
23. Been thinking of yourself as a worthless person	Not at all	No more than usual	Rather more than usual	Much more than usual
24. Felt that life is entirely hopeless	Not at all	No more than usual	Rather more than usual	Much less than usual
25. Been feeling hopeful about your own future	More so than usual	About the same as usual	Less so than usual	Much less hopeful
26. Been feeling reasonably happy all things considered	More so than usual	About the same as usual	Less so than usual	Much less than usual
27. Been feeling nervous and and strung up all the time	Not at all	No more than usual	Rather more than usual	Much more than usual

28. Felt that life is not worth living	Not at all	No more than usual	Rather more than usual	Much more than usual
29. Found at times you could not do anything because your nerves were so bad	Not at all	No more than usual	Rather more than usual	Much more than usual

5. <u>Multiple Affect Adjective Check List</u>

<u>Directions</u>: On this sheet you will find words which describe different kinds of moods and feelings. Tick the words which describe how your feel <u>now</u> - <u>today</u>. Some of the words may sound alike, but we want you to check all the words that describe your feelings.

1 active
2 adventurous
3 affectionate
4 afraid
5 agitated
6 agreeable
7 aggressive
8 alive
9 alone
10 amiable
11 amused
12 angry
13 annoyed
14 awful
15 bashful
16 bitter
17 blue
18 bored
19 calm
20 cautious
21 cheerful
22 clean
23 complaining
24 contented
25 contrary
26 cool
27 cooperative
28 critical
29 cross
45 fit
46 forlorn
47 frank
48 free
49 friendly
50 frightened
51 furious
52 gay
53 gentle
54 glad
55 gloomy
56 good
57 good-natured
58 grim
59 happy
60 healthy
61 hopeless
62 hostile
63 impatient
64 incensed
65 indignant
66 inspired
67 interested
68 irritated
69 jealous
70 joyful
71 kindly
72 lonely
73 lost
89 peaceful
90 pleased
91 pleasant
92 polite
93 powerful
94 quiet
95 reckless
96 rejected
97 rough
98 sad
99 safe
100 satisfied
101 secure
102 shaky
103 shy
104 soothed
105 steady
106 stubborn
107 stormy
108 strong
109 suffering
110 sullen
111 sunk
112 sympathetic
113 tame
114 tender
115 tense
116 terrible
117 terrified

30 cruel
31 daring
32 desperate
33 destroyed
34 devoted
35 disagreeable
36 discontented
37 discouraged
38 disgusted
39 displeased
40 energetic
41 enraged
42 enthusiastic
43 fearful
44 fine

74 loving
75 low
76 lucky
77 made
78 mean
79 meek
80 merry
81 mild
82 miserable
83 nervous
84 obliging
85 offended
86 outraged
87 panicky
88 patient

118 thoughtful
119 timid
120 tormented
121 understanding
122 unhappy
123 unsociable
124 upset
125 vexed
126 warm
127 whole
128 wild
129 willful
130 wilted
131 worrying
132 young

6. Semantic Differential

Instructions: We are trying to see what people mean by certain things. We want you to judge your own attitudes or beliefs towards or about things. Under each heading in the following pages there are a set of adjectives relating to the head. We want you to rate your own feeling about the adjectives in relation to the headings.

Here is how to do it:

If you feel that the thing at the top of the section is very closely related to one end, you should place a cross as follows:

fair _x_ : ___ : ___ : ___ : ___ : ___ : ___ unfair

or

fair ___ : ___ : ___ : ___ : ___ : ___ : _x_ unfair

If you feel that the thing is quite closely related to one or other end (but not very), you should place a cross as follows:

strong ___ : _x_ : ___ : ___ : ___ : ___ : ___ weak

or

strong ___ : ___ : ___ : ___ : ___ : _x_ : ___ weak

If the thing seems only slightly related to one side as opposed to the other side (but is not equally right in the middle), then you should check as follows:

active ___ : ___ : _x_ : ___ : ___ : ___ : ___ passive

or

active ___ : ___ : ___ : ___ : _x_ : ___ : ___ passive

Which way you put the cross, of course, depends upon which of the two ends of the scale seems most true of the thing you are judging.

If you consider the thing to be not really related to either side, or equally related to both sides, you should put your cross right in the middle:

safe ___ : ___ : ___ : _x_ : ___ : ___ : ___ dangerous

IMPORTANT:

(1) Place the cross in the middle of the boxes, not on the sides:

THIS NOT THIS

x

___ : ___ : ___ : _x_ : ___ : ___ : ___

(2) Be sure you check every scale for every concept - do not leave any out.

(3) Never put more than one cross on a single scale.

Sometimes you may feel as though you have had the same item before on the test. This will not be the case, so do not look back and forth through the items. Do not try to remember how you checked similar items earlier in the test.

Make each item a separate and independent judgment. Work fairly quickly through this test. Do not worry or puzzle over each item. It is your first impressions, the immediate "feelings" about these items, that we want. On the other hand, please do not be careless, because we want your impressions.

SAMPLE PAGE

MY MOTHER

fair	x							unfair
strong			x					weak
active		x						passive
safe	x							dangerous

<u>WHAT I THINK MY TREATMENT WILL BE LIKE</u>

strong	___ : ___ : ___ : ___ : ___ : ___ : ___	weak
safe	___ : ___ : ___ : ___ : ___ : ___ : ___	dangerous
pleasant	___ : ___ : ___ : ___ : ___ : ___ : ___	unpleasant
worthless	___ : ___ : ___ : ___ : ___ : ___ : ___	valuable
long	___ : ___ : ___ : ___ : ___ : ___ : ___	short
laborious	___ : ___ : ___ : ___ : ___ : ___ : ___	effortless
boring	___ : ___ : ___ : ___ : ___ : ___ : ___	interesting
bad	___ : ___ : ___ : ___ : ___ : ___ : ___	good
fast	___ : ___ : ___ : ___ : ___ : ___ : ___	slow
old	___ : ___ : ___ : ___ : ___ : ___ : ___	new
nice	___ : ___ : ___ : ___ : ___ : ___ : ___	awful

THE TREATMENT I SHALL RECEIVE WILL BE SUCCESSFUL

unlikely	___ : ___ : ___ : ___ : ___ : ___ : ___	likely
possible	___ : ___ : ___ : ___ : ___ : ___ : ___	impossible
improbable	___ : ___ : ___ : ___ : ___ : ___ : ___	probable
true	___ : ___ : ___ : ___ : ___ : ___ : ___	false

THE TREATMENT I SHALL RECEIVE WILL COMPLETELY CURE ME

probable	___ : ___ : ___ : ___ : ___ : ___ : ___	improbable
impossible	___ : ___ : ___ : ___ : ___ : ___ : ___	possible
false	___ : ___ : ___ : ___ : ___ : ___ : ___	true
likely	___ : ___ : ___ : ___ : ___ : ___ : ___	unlikely

MY BRONCHITIS

sick	___ : ___ : ___ : ___ : ___ : ___ : ___	healthy
nice	___ : ___ : ___ : ___ : ___ : ___ : ___	awful
is never a nuisance	___ : ___ : ___ : ___ : ___ : ___ : ___	is always a nuisance
pleasurable	___ : ___ : ___ : ___ : ___ : ___ : ___	painful
does not make me feel bitter	___ : ___ : ___ : ___ : ___ : ___ : ___	makes me feel bitter
causes financial worries	___ : ___ : ___ : ___ : ___ : ___ : ___	does not cause financial worries
bad	___ : ___ : ___ : ___ : ___ : ___ : ___	good
strong	___ : ___ : ___ : ___ : ___ : ___ : ___	weak
rugged	___ : ___ : ___ : ___ : ___ : ___ : ___	delicate
unpleasant	___ : ___ : ___ : ___ : ___ : ___ : ___	pleasant

MY BRONCHITIS CAN BE IMPROVED

impossible	___ : ___ : ___ : ___ : ___ : ___ : ___	possible
probable	___ : ___ : ___ : ___ : ___ : ___ : ___	improbable
false	___ : ___ : ___ : ___ : ___ : ___ : ___	true
likely	___ : ___ : ___ : ___ : ___ : ___ : ___	unlikely

MY BRONCHITIS IS A LONG TERM CONDITION

false	___ : ___ : ___ : ___ : ___ : ___ : ___	true
likely	___ : ___ : ___ : ___ : ___ : ___ : ___	unlikely
possible	___ : ___ : ___ : ___ : ___ : ___ : ___	impossible
improbable	___ : ___ : ___ : ___ : ___ : ___ : ___	probable

MYSELF

healthy	___ : ___ : ___ : ___ : ___ : ___ : ___	sick
awful	___ : ___ : ___ : ___ : ___ : ___ : ___	nice
passive	___ : ___ : ___ : ___ : ___ : ___ : ___	active
pleasant	___ : ___ : ___ : ___ : ___ : ___ : ___	unpleasant
unsociable	___ : ___ : ___ : ___ : ___ : ___ : ___	sociable
hard	___ : ___ : ___ : ___ : ___ : ___ : ___	soft
bad	___ : ___ : ___ : ___ : ___ : ___ : ___	good
rugged	___ : ___ : ___ : ___ : ___ : ___ : ___	delicate
dependent	___ : ___ : ___ : ___ : ___ : ___ : ___	independent
slow	___ : ___ : ___ : ___ : ___ : ___ : ___	fast
unemotional	___ : ___ : ___ : ___ : ___ : ___ : ___	emotional
strong	___ : ___ : ___ : ___ : ___ : ___ : ___	weak

<u>MYSELF AS I WOULD LIKE TO BE</u>

sociable	___ : ___ : ___ : ___ : ___ : ___ : ___	unsociable
unpleasant	___ : ___ : ___ : ___ : ___ : ___ : ___	pleasant
soft	___ : ___ : ___ : ___ : ___ : ___ : ___	hard
rugged	___ : ___ : ___ : ___ : ___ : ___ : ___	delicate
awful	___ : ___ : ___ : ___ : ___ : ___ : ___	nice
active	___ : ___ : ___ : ___ : ___ : ___ : ___	passive
bad	___ : ___ : ___ : ___ : ___ : ___ : ___	good
strong	___ : ___ : ___ : ___ : ___ : ___ : ___	weak
healthy	___ : ___ : ___ : ___ : ___ : ___ : ___	sick
dependent	___ : ___ : ___ : ___ : ___ : ___ : ___	independent
unemotional	___ : ___ : ___ : ___ : ___ : ___ : ___	emotional
fast	___ : ___ : ___ : ___ : ___ : ___ : ___	slow

MY FAMILY

hard	___ : ___ : ___ : ___ : ___ : ___ : ___	soft
bad	___ : ___ : ___ : ___ : ___ : ___ : ___	good
do not need me	___ : ___ : ___ : ___ : ___ : ___ : ___	need me
strong	___ : ___ : ___ : ___ : ___ : ___ : ___	weak
unpleasant	___ : ___ : ___ : ___ : ___ : ___ : ___	pleasant
nice	___ : ___ : ___ : ___ : ___ : ___ : ___	awful
understand my problems	___ : ___ : ___ : ___ : ___ : ___ : ___	do not understand my problems
independent	___ : ___ : ___ : ___ : ___ : ___ : ___	dependent
unemotional	___ : ___ : ___ : ___ : ___ : ___ : ___	emotional
helpful	___ : ___ : ___ : ___ : ___ : ___ : ___	unhelpful
unsympathetic	___ : ___ : ___ : ___ : ___ : ___ : ___	sympathetic

THE EFFECT OF MY BRONCHITIS ON MY FAMILY

unpleasant	___ : ___ : ___ : ___ : ___ : ___ : ___	pleasant
strong	___ : ___ : ___ : ___ : ___ : ___ : ___	weak
unimportant	___ : ___ : ___ : ___ : ___ : ___ : ___	important
good	___ : ___ : ___ : ___ : ___ : ___ : ___	bad
large	___ : ___ : ___ : ___ : ___ : ___ : ___	small
decreasing	___ : ___ : ___ : ___ : ___ : ___ : ___	increasing
kind	___ : ___ : ___ : ___ : ___ : ___ : ___	cruel
complex	___ : ___ : ___ : ___ : ___ : ___ : ___	simple
awful	___ : ___ : ___ : ___ : ___ : ___ : ___	nice

MY WORK

worthless	___ : ___ : ___ : ___ : ___ : ___ : ___	valuable
necessary for me	___ : ___ : ___ : ___ : ___ : ___ : ___	unnecessary for me
safe	___ : ___ : ___ : ___ : ___ : ___ : ___	dangerous
unimportant	___ : ___ : ___ : ___ : ___ : ___ : ___	important
fast	___ : ___ : ___ : ___ : ___ : ___ : ___	slow
heavy	___ : ___ : ___ : ___ : ___ : ___ : ___	light
bad	___ : ___ : ___ : ___ : ___ : ___ : ___	good
worse than being unemployed	___ : ___ : ___ : ___ : ___ : ___ : ___	better than being unemployed
active	___ : ___ : ___ : ___ : ___ : ___ : ___	passive
soft	___ : ___ : ___ : ___ : ___ : ___ : ___	hard
nice	___ : ___ : ___ : ___ : ___ : ___ : ___	awful

I WILL BE GOING BACK TO WORK/CONTINUING WORK

true	___ : ___ : ___ : ___ : ___ : ___ : ___	false
impossible	___ : ___ : ___ : ___ : ___ : ___ : ___	possible
likely	___ : ___ : ___ : ___ : ___ : ___ : ___	unlikely
improbable	___ : ___ : ___ : ___ : ___ : ___ : ___	probable

PHYSICAL EXERCISE

slow	___ : ___ : ___ : ___ : ___ : ___ : ___	fast
valuable	___ : ___ : ___ : ___ : ___ : ___ : ___	worthless
pleasant	___ : ___ : ___ : ___ : ___ : ___ : ___	unpleasant
weak	___ : ___ : ___ : ___ : ___ : ___ : ___	strong
safe	___ : ___ : ___ : ___ : ___ : ___ : ___	dangerous
bad	___ : ___ : ___ : ___ : ___ : ___ : ___	good
awful	___ : ___ : ___ : ___ : ___ : ___ : ___	nice
important	___ : ___ : ___ : ___ : ___ : ___ : ___	unimportant
soft	___ : ___ : ___ : ___ : ___ : ___ : ___	hard

PHYSICAL EXERCISE IS GOOD FOR ME

probable	___ : ___ : ___ : ___ : ___ : ___ : ___	improbable
impossible	___ : ___ : ___ : ___ : ___ : ___ : ___	possible
unlikely	___ : ___ : ___ : ___ : ___ : ___ : ___	likely
true	___ : ___ : ___ : ___ : ___ : ___ : ___	false

MY GENERAL HEALTH

awful	___ : ___ : ___ : ___ : ___ : ___ : ___	nice
rugged	___ : ___ : ___ : ___ : ___ : ___ : ___	delicate
sick	___ : ___ : ___ : ___ : ___ : ___ : ___	healthy
pleasurable	___ : ___ : ___ : ___ : ___ : ___ : ___	painful
pleasant	___ : ___ : ___ : ___ : ___ : ___ : ___	unpleasant
bad	___ : ___ : ___ : ___ : ___ : ___ : ___	good
weak	___ : ___ : ___ : ___ : ___ : ___ : ___	strong

SMOKING

wise	___ : ___ : ___ : ___ : ___ : ___ : ___	foolish
light	___ : ___ : ___ : ___ : ___ : ___ : ___	heavy
sociable	___ : ___ : ___ : ___ : ___ : ___ : ___	unsociable
pleasant	___ : ___ : ___ : ___ : ___ : ___ : ___	unpleasant
bad	___ : ___ : ___ : ___ : ___ : ___ : ___	good
weak	___ : ___ : ___ : ___ : ___ : ___ : ___	strong
valuable	___ : ___ : ___ : ___ : ___ : ___ : ___	worthless
dangerous	___ : ___ : ___ : ___ : ___ : ___ : ___	safe
nice	___ : ___ : ___ : ___ : ___ : ___ : ___	awful
soothing	___ : ___ : ___ : ___ : ___ : ___ : ___	aggravating

APPENDIX II

AGE, SEX AND PHYSIOLOGICAL DATA [STUDY I]

No.	Age	Sex	FEV1(L)	FVC(L)	Pa02kpa	PaCO2kPa
1	70	M	1.1	4.1	7.3	4.4
2	70	M	1.3	3.5	10.4	5.1
3	65	F	0.4	1.99	8.1	6.2
4	66	M	1.25	3.05	8.5	5.4
5	55	F	0.35	1.1	6.4	6.9
6	44	M	1.7	3.3	10.0	4.8
7	64	F	0.82	2.3	7.5	4.6
8	60	M	1.2	1.8	7.4	5.4
9	58	M	1.55	2.6	8.5	4.9
10	42	M	3.5	5.2	10.5	4.8
11	57	M	0.25	1.3	6.9	6.4
12	55	M	1.2	2.35	7.3	5.3
13	62	M	1.7	3.8	10.3	5.9
14	60	F	0.65	1.0	7.6	4.0
15	51	M	0.95	2.65	7.8	5.5

No.	Age	Sex	FEV1(L)	FVC(L)	Pa02kpa	PaCO2kPa
16	69	M	1.22	3.7	7.3	4.0
17	51	M	0.62	2.94	8.2	5.7
18	62	M	1.21	3.3	9.2	4.3
19	64	M	1.21	3.95	8.8	5.2
20	69	M	0.62	2.2	8.0	6.1
21	67	M	0.75	3.5	8.3	5.3
22	58	M	0.55	2.0	8.3	6.3
23	63	M	0.6	1.85	-	-
24	60	F	0.35	1.35	7.5	6.5
25	60	M	1.1	3.35	6.8	6.9
26	52	M	0.35	1.7	7.6	6.8
27	59	M	2.8	5.1	10.0	4.9
28	70	F	0.7	1.65	10.1	5.4
29	69	M	1.2	2.5	8.4	6.4
30	69	M	0.75	3.05	6.7	4.8
31	59	M	0.7	2.21	-	-
32	55	M	0.6	1.45	7.9	6.8

No.	Age	Sex	FEV1(L)	FVC(L)	Pa02kpa	PaCO2kPa
33	54	M	0.25	1.34	8.3	5.9
34	53	M	0.85	3.15	9.1	5.7
35	64	F	1.4	1.8	10.4	4.7
36	59	F	0.6	1.52	8.4	5.3
37	68	F	1.5	2.8	10.5	4.7
38	70	M	1.3	3.3	7.1	5.3
39	55	M	0.62	2.05	8.5	5.9
40	54	M	0.4	1.5	8.2	7.2
41	55	M	0.85	3.35	8.5	5.4
42	70	M	1.2	2.8	8.7	5.2
43	55	M	0.6	2.4	8.7	6.1
44	62	F	0.5	1.8	8.2	5.4
45	69	M	0.85	2.3	5.6	4.6
46	60	M	1.0	2.5	9.6	6.5
47	56	M	1.0	3.6	6.8	7.8
48	61	M	0.48	2.72	8.9	4.1
49	59	M	0.35	1.4	9.7	5.8
50	65	M	0.75	2.05	9.7	5.7

RESULTS FOR QUESTIONNAIRES AND TWELVE MINUTE WALKING TESTS.

MRC : Medical Research Council Grade

12MD : Twelve minute walking distance (metres)

RPE : Borg's "Perceived Exertion" (scale 6-19)

GHQ : General Health Question (scale 0-30)

DBQ : "Disproportionate breathlessness" questionnaire (scale 0-10)

Aniety]
from "multiple affect adjective check list"
Depression]
(scale 0-25)
Hostility]

NO.	MRC	12MD (M)	RPE	GHQ	DBQ
1	4	770	15	0	3
2	4	380	17	17	9
3	4	780	15	12	4
4	4	1080	15	8	5
5	5	350	15	0	6
6	3	1040	15	19	6
7	4	982	12	12	3

NO.	MRC	12MD (M)	RPE	GHQ	DBQ
8	3	985	12	6	3
9	4	680	15	15	5
10	-	1100	17	0	5
11	5	470	13	14	5
12	1	765	15	7	3
13	3	970	11	24	-
14	3	1150	13	9	5
15	5	480	14	25	7
16	5	205	17	20	8
17	3	824	15	23	6
18	5	743	13	10	6
19	4	1375	11	9	2
20	4	760	19	0	5
21	4	923	15	0	3
22	5	960	17	7	5
23	5	762	16	10	3
24	4	755	19	6	5
25	4	1180	17	10	7

NO.	MRC	12MD (M)	RPE	GHQ	DBQ
26	4	880	15	8	3
27	3	979	13	8	-
28	4	360	17	7	0
29	4	300	17	23	3
30	4	1065	13	0	4
31	4	1002	15	23	5
32	4	900	15	13	4
33	4	635	15	2	6
34	4	1040	13	28	8
35	4	834	17	13	4
36	3	940	13	18	6
37	2	690	15	19	4
38	4	360	17	16	5
39	4	845	17	8	5
40	5	250	15	15	6
41	4	950	11	15	6
42	3	780	12	5	0

NO.	MRC	12MD (M)	RPE	GHQ	DBQ
43	4	320	17	11	5
44	4	300	19	26	0
45	3	640	15	3	2
46	4	900	13	15	4
47	3	1460	13	23	6
48	5	665	13	9	7
49	4	363	17	21	6
50	3	957	11	16	4

DETAILS OF PATIENTS

<u>An</u>iety]
From "multiple affect adjective check list"
<u>De</u>pression]
(scales 0-25)
<u>Ho</u>stility]

NO.	ANX	DEP	HOS
1	10	19	13
2	12	19	12

NO.	ANX	DEP	HOS
3	11	21	12
4	2	9	2
5	8	19	11
6	15	15	12
7	11	19	7
8	4	14	2
9	3	14	4
10	8	17	11
11	9	17	10
12	8	17	7
13	9	20	12
14	13	20	11
15	11	20	12
16	10	21	13
17	10	23	12
18	8	16	7
19	1	2	0
20	6	15	8

NO.	ANX	DEP	HOS
21	1	11	3
22	12	20	11
23	8	15	7
24	10	16	4
25	10	15	10
26	12	20	12
27	5	18	5
28	13	22	12
29	13	22	12
30	0	2	1
31	13	19	5
32	0	4	1
33	1	14	5
34	15	22	10
35	13	22	10
36	11	23	12
37	10	20	12
38	10	20	7

NO.	ANX	DEP	HOS
39	3	7	4
40	12	22	12
41	9	14	9
42	12	20	11
43	11	20	12
44	16	21	12
45	8	19	10
46	11	21	13
47	4	11	2
48	7	13	2
49	10	19	7
50	17	24	17

Appendix III Study II - Age and Physiological Data

No.	Age (yrs)	FEV_1(L)	VC(L)	D_LCO (mmol/min /kPa)	KCO (mmol/min /kPa/L)
1	73	0.7	3.3	-	-
2	71	1.7	3.3	8.39	1.43
3	57	0.3	2.2	-	-
4	57	0.3	1.5	3.6	1.05
5	56	0.5	2.8	5.04	0.69
6	52	3.5	4.6	10.25	1.44
7	65	2.4	4.3	8.4	1.22
8	67	0.8	3.1	5.45	1.04
9	68	0.9	2.2	2.53	0.67
10	67	0.5	2.6	2.33	0.58
11	63	1.0	2.7	2.89	0.7
12	62	3.0	5.0	7.46	1.27
13	71	2.3	4.2	4.06	0.67
14	63	2.7	4.0	8.35	1.35
15	64	0.4	2.5	2.27	0.58
16	54	0.6	2.7	3.37	0.64
17	64	2.3	3.5	9.48	1.4
18	64	2.3	3.6	6.63	1.19
19	63	1.4	2.8	7.6	1.29
20	62	1.4	3.0	5.74	1.13
21	62	2.1	3.5	5.73	1.14
22	66	1.8	3.8	7.3	1.21

Appendix III   Study II - Arterial Blood Gases

No.	PaO_2 (kPa)	$PaCO_2$ (kPa)
1	8.0	4.5
2	8.4	5.1
3	-	-
4	4.5	6.9
5	8.3	5.9
6	-	-
7	9.1	5.2
8	9.5	4.8
9	12.0	5.3
10	6.0	7.9
11	8.9	4.5
12	9.1	4.5
13	10.4	4.9
14	12.9	4.1
15	-	-
16	9.6	5.7
17	10.8	4.5
18	11.1	4.7
19	7.9	5.2
20	9.4	4.4
21	10.0	4.5
22	8.4	3.9

Appendix III   Study II - 2, 6 and 12 MD

No.	2	6	12
1	137	358	709
2	165	475	950
3	195	237	515
4	87	180	406
5	122	247	460
6	197	539	997
7	161	469	942
8	142	417	852
9	99	232	408
10	167	458	857
11	126	363	668
12	218	655	1285
13	180	517	1017
14	200	578	1105
15	193	392	680
16	160	316	642
17	168	502	980
18	180	562	1119
19	168	490	986
20	155	443	962
21	233	633	1189
22	193	561	1088